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Healthcare

Puritan
Bennett

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Technical Manual

HELiOS™ Liquid Oxygen Reservoirs
(Standard and Universal)
HELiOS™ Liquid Oxygen Portables

Part Number B-701693-00 Rev. C (10/02)

CAUTION: Federal (U.S.A.) laws restricts this device to sale by or on the order of a physician.

LIST OF EFFECTIVE PAGES

This list of effective pages represents manual P/N B-701693-00, Revision C.

Revision	Description	Date
A	Initial Release	05-00
B	Page Information Changes	10-01
C	Universal Res. & Parts Illus. Changes	10-02

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NOTE: SI pressure values expressed in manual are referenced to atmosphere.

DEFINITION OF STATEMENTS

Statements in this manual preceded by the following words are of special significance:

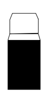
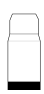
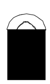
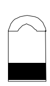
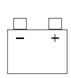
WARNING

⚠ A warning describes conditions that concern your personal safety and the safety of others. It includes the actions required to prevent injury. Ignoring warnings can lead to injury or death.

⚠ CAUTION: A caution informs you about conditions that may cause possible damage to the equipment or other property, or situations that may cause reduced or no oxygen flow.

NOTE: Notes provide important information about using the equipment properly.

DEFINITION OF PRODUCT SYMBOLS

SYMBOL	DEFINITION	SYMBOL	DEFINITION
	Reservoir Full		Do not smoke near unit
	Reservoir Empty		Keep unit well venti-lated at all times
	Portable Full		Do not touch frosted parts
	Portable Empty		Keep unit in upright position
	Low Battery (9VDC)		Keep unit upright, flat on its back, or any position in between
IPX1	Drip Proof		
	Type BF (Electrical Safety)		

PREFACE

This manual provides the information needed to service the Puritan Bennett HELiOS Standard Reservoir, Universal Reservoir, and H300 Portable units. Information in the first section of this manual covers both the Reservoir and the Portable units. Information in Sections 2 through 7 covers just the Reservoir unit. Information in Sections 8 through 13 covers just the HELiOS 300 Portable unit. **This information is intended for use by technicians or personnel qualified to repair and service medical liquid oxygen equipment.** Do not attempt to fill or repair these units until you read and understand the information in this manual.

The following document contains additional information useful in servicing this equipment:

- HELiOS Oxygen System Operating Instructions: P/N B-701641-00

For product assistance contact:

Puritan-Bennett Corp.
2800 Airwest Blvd.
Plainfield, IN 46168
Customer Service:
1-800-635-5267, press 2
Technical Support:
1-800-255-6774, press 2
www.heliosoxygen.com

NOTE: HELiOS Reservoir and Portable units are intended only for the delivery of medical grade oxygen as prescribed by a physician.

WARNING

Improper usage hazard. Oxygen supplied from this equipment is for supplemental use and is not intended to be life supporting or life sustaining. This equipment is not intended for use by patients who would suffer immediate, permanent, or serious health consequences as a result of an interruption in their oxygen supply.

CAUTION: Consistent with the recommendations of the medical community on the use of conserving devices (which includes the nasal cannula), it is recommended that the HELiOS system be qualified on patients in the situations it will be used (rest, exercise, sleep). Differences in nasal cannula design may vary the ability to trigger a conserving device.

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Technical Bulletins

INTRODUCTION TO THE HELiOS SYSTEM

Section 1

WARNING

Read Section 1, and any other applicable section, thoroughly before attempting to service or fill a HELiOS Reservoir or Portable. Failure to do so may result in injury or death.

The HELiOS is an innovative liquid oxygen system where the Reservoir and Portable unit provide a new level of performance efficiency for oxygen therapy patients. This section provides introductory information on the HELiOS liquid oxygen system. It includes a brief system description; serial number identification; safety precautions; liquid oxygen saturation fundamentals; pressure fittings and connections information; tool, test equipment, and service material recommendations; test equipment calibration information; and accessory information.

The information in this section relates to both the Reservoir and the Portable units. Sections 2 through Section 7 provide technical and service information that is specific to the HELiOS Standard Reservoir and Universal Reservoir units. Sections 8 through Section 13 provide technical and service information that is specific to the HELiOS 300 Portable unit.

1.1 HELIOS SYSTEM DESCRIPTION

The HELiOS liquid oxygen system provides 24 hour per day reservoir and portable oxygen therapy for a typical Chronic Obstructive Pulmonary Disease (COPD) patient. HELiOS uses oxygen conservation and exclusive “no loss” technology to greatly improve performance efficiency compared to conventional liquid oxygen systems. The HELiOS Reservoir unit redefines the evaporative loss characteristics of home liquid oxygen vessels and has features that enhance the safety and usability of the product. Using the H300 Portable with a Standard HELiOS Reservoir will typically require less than one liquid oxygen delivery to the patient per month. The HELiOS Universal Reservoir has many of the same features as the Standard Reservoir plus it permits filling the H300 Portable as well as the Puritan Bennett Companion 1000, Companion T, and Companion 500 series portables. The HELiOS 300 Portable unit sets a new standard for size, weight, and range that surpasses existing cylinder or liquid based portables.

Like today's liquid oxygen systems, the HELiOS system consists of a Reservoir and a Portable patient unit (Figure 1-1). However, the system components are capable of working together rather than separately. The HELiOS 300 Portable fills from the Reservoir for ambulatory use or connects to the Reservoir with a flexible oxygen supply tube for home use. This provides the patient with the same familiar interface whether at home or away.

Figure 1-1: HELiOS Reservoir and Portable

The patient receives oxygen from the H-300 Portable through a dual lumen cannula and a pneumatic demand flow control system. The H-300 Portable provides 11 different oxygen flow settings from .12 through 4 . Flow settings from 1 through 4 provide demand flow oxygen to the patient on each inspiration. No oxygen flows during exhalation. Flow settings less than 1 provide continuous oxygen flow (L/min) to the patient at the indicated rate. The demand flow control system in a full H-300 Portable can provide a 2 L/min patient with up to 10 hours of demand flow oxygen. This results in a 4:1 oxygen savings while still providing adequate oxygen to meet the patient's needs.

For ambulatory use, the patient fills the H-300 Portable with liquid oxygen from the Reservoir. When full, it holds slightly less than one pound (454 grams) of liquid oxygen and weighs a total of 3.6 pounds (1.6 kg). A spring scale type contents indicator shows the amount of liquid oxygen remaining in the unit.

For oxygen needs in the home, the patient engages the H-300 Portable to a flexible oxygen supply tube that connects to the oxygen outlet of the Reservoir. The H-300 Portable provides the patient with the same familiar oxygen delivery interface but the patient now breathes gaseous oxygen directly from the Reservoir. This makes the H-300 Portable about one pound (454 grams) lighter since it contains no liquid oxygen. Also, evaporative oxygen losses from the Reservoir are greatly reduced since the patient breathes the gas that normally builds pressure and vents through the Reservoir relief valve.

Two HELiOS Reservoir models are available in both 36 liter and 46 liter sizes. The Standard H-36 and H-46 Reservoirs provide the patient with both a means to fill a HELiOS Portable with liquid oxygen and a source of regulated 22 psig (152 kPa) gaseous oxygen for breathing with the H-300 Portable or other external 22 psig (152 kPa) flow-metering device. The Universal U-36 and U-46 Reservoirs also provide the patient with both a means to fill a HELiOS Portable with liquid oxygen and a source of 22 psig (152 kPa) gaseous oxygen. In addition, lower internal pressure in the Universal Reservoir permits the filling of Puritan

Bennett Companion portables as well. At the push of a button, an electronic contents indicator measures and displays the amount of liquid oxygen remaining in the Reservoir.

The H-36 Reservoir, when used with an H-300 Portable, typically yields a four week liquid oxygen delivery cycle with a 2 L/min patient. The U-36 Reservoir, when used with an H-300 Portable, typically yields almost a four week liquid oxygen delivery cycle with a 2 L/min patient.

The H-46 Reservoir, when used with an H-300 Portable, can yield a six week liquid oxygen delivery cycle with a 2 L/min patient. The U-46 Reservoir, when used with an H-300 Portable, can yield a five week liquid oxygen delivery cycle with a 2 L/min patient.

1.2 SERIAL NUMBER IDENTIFICATION

Each HELiOS Reservoir and H-300 Portable are identified by a unique eight-digit serial number. The number contains the year and calendar day of manufacture, as well as the unit's production number for that day (Figure 1-2). The Standard Reservoir serial number is etched into the upper head of the cryogenic container and is visible when the moisture container is removed (Figure 1-3). The Universal Reservoir serial number is etched into a Reservoir handle bracket. The H-300 Portable serial number is etched into the cryogenic container and is visible through the contents indicator window in the rear side cover (Figure 1-4).

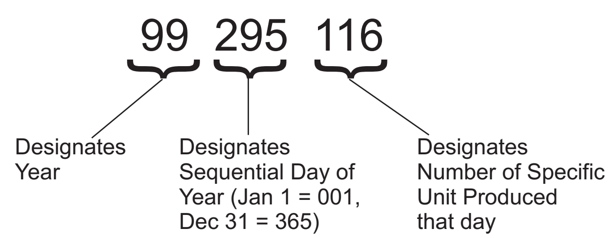


Figure 1-2: Serial Number Scheme

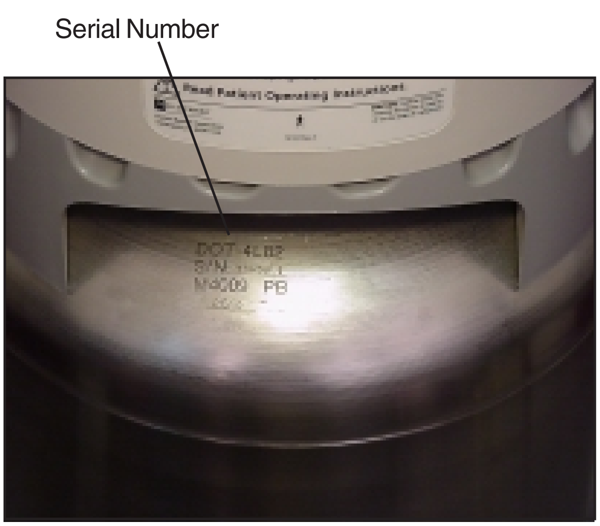


Figure 1-3:
Standard Reservoir Serial Number Location

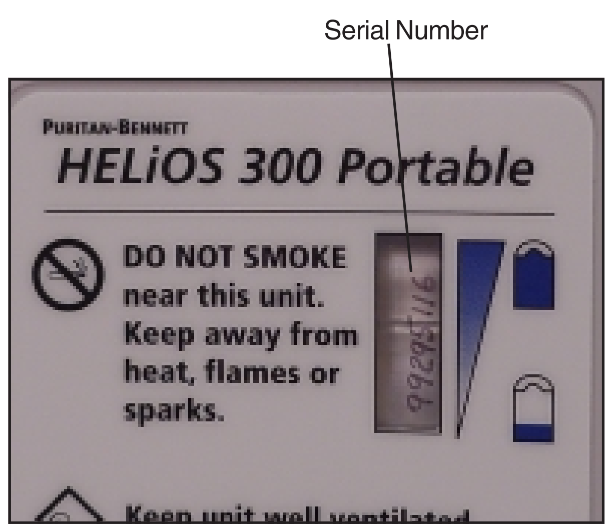


Figure 1-4:
H-300 Serial Number Location

1.3 SAFETY PRECAUTIONS

This section covers precautions and safe practices as they apply to facilities and personnel involved in servicing medical oxygen equipment. These precautions are divided into three main areas: cold safety, expansion safety, and fire safety. To ensure reliability and safety, the service techniques, work area, and equipment used in the storage, service, and handling of this system must be of the highest standard. Refer to the HELiOS Operating Instructions (B-701641-00) for additional safety precautions regarding the use of this equipment.

1.3.1 Cold Safety

WARNING

Extreme cold hazard. Liquid oxygen is extremely cold (-297°F/-183°C) and will freeze skin on contact. Never touch liquid oxygen or frosted parts.

WARNING

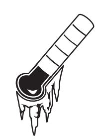
Extreme cold hazard. Liquid oxygen can spill if the Reservoir is tipped over. Keep the Reservoir upright at all times. Secure the Reservoir when transporting to prevent accidental tip-over.

WARNING

Extreme cold hazard. Liquid oxygen can spill from the Portable. Always keep the Portable in one of the following positions; upright, flat on its back or any position in between.

WARNING

Extreme cold hazard. Forceful discharge of liquid oxygen possible if fill connector freezes open upon disengagement. Always dry fill connectors with clean, dry lint free cloth before fill.



Recommended Protective Clothing:

- **Heavily insulated gloves** (for example, cryogenic or welding gloves). Never use gloves that are contaminated with grease or oil when working with liquid oxygen.
- **Protective face shield and goggles.**
- **Long sleeve shirt.** Wear natural fibers such as cotton or wool. Avoid synthetic materials such as polyester or rayon.
- **Long pants.** Never wear pants with cuffs. Liquid oxygen may become trapped and cause serious burns to skin. Wear natural fibers such as cotton or wool. Avoid synthetic materials such as polyester or rayon.
- **Protective cryogenic or welding apron.**

Important Facts:

- Direct exposure to liquid oxygen or exposure to its vented gas or components cooled by liquid oxygen can result in frostbite. If frostbite occurs, seek medical attention immediately.

1.3.2 Expansion Safety

WARNING

Explosive hazard. Extreme high pressure can rupture container or plumbing components. Be sure specified pressure relief devices are present, in the proper location, and functioning properly.

Important Facts:

- Liquid oxygen at atmospheric pressure expands at a ratio of approximately 860:1 (at 0 psig) when vaporizing into a gas (Figure 1-5). This can occur very rapidly when exposed to the heat in the atmosphere.
- Ensure that the specified pressure relief devices are present and functioning properly in **any device** that will contain liquid oxygen. This includes transfer hose assemblies.

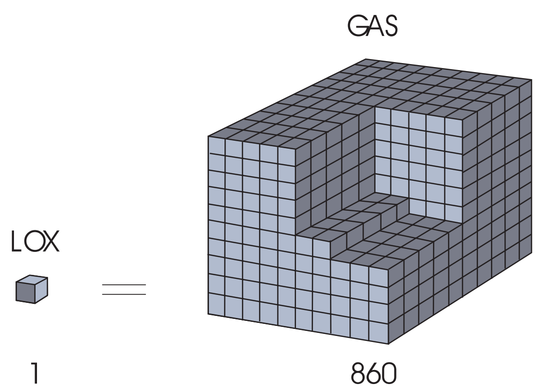


Figure 1-5: Liquid Oxygen Expansion Ratio

1.3.3 Fire Safety

WARNING

Concentrated Oxygen. Increased risk of fire.

• Do not smoke or keep burning tobacco near this equipment. Death or injury may occur.

• Keep flammable materials away from this equipment. Oils, grease, including facial creams and petroleum jelly, asphalt, and synthetic fibers ignite easily and burn rapidly in the presence of concentrated oxygen. If needed, use only specified oxygen compatible lubricants as directed.

• Keep oxygen equipment away from open flames. Keep Reservoir and Portable units at least five feet away from equipment such as furnaces, water heaters, and stoves that may contain open flames.

WARNING

Concentrated Oxygen. Increased risk of fire.

• Keep oxygen equipment away from electrical appliances. Keep Reservoir and Portable units at least five feet from electrical appliances that may cause heat or sparks.

• Keep oxygen equipment in a well-ventilated area at all times. These units periodically release small amounts of oxygen gas that must be ventilated to prevent buildup. Do not store liquid oxygen equipment in a car trunk, closet, or other confined area. Do not place bags, blankets, draperies, or other fabrics over the equipment when it contains liquid oxygen.

• Do not place the Portable unit under clothing. These units normally vent oxygen. Placing a Portable unit under clothing may saturate fabrics with oxygen and cause them to burn rapidly if exposed to sparks or flame. It may take several hours for oxygen levels in the fabric to return to normal.

Important Facts:

The possibility of fire exists when the combination of a fuel, source of ignition, and oxygen is present (Figure 1-6). High concentrations of oxygen (air is approximately 21% oxygen) greatly enhance the possibility of combustion.

- Obtain all replacement parts for medical oxygen equipment from the manufacturer.
- Before servicing, clean all tools that come into contact with the oxygen system.
- Use only recommended oxygen compatible cleaning and leak detection products.
- Keep the Reservoir upright at all times. Secure liquid oxygen equipment when transporting to prevent accidental tipover and spillage.
- If a liquid oxygen spill occurs indoors, open doors and windows to ventilate the area. Avoid sources of ignition and do not walk on or roll equipment over the affected area.
- Any clothing or porous material that is splashed with liquid oxygen or otherwise absorbs high concentrations of oxygen should be removed and aired for at least one hour away from any source of ignition.

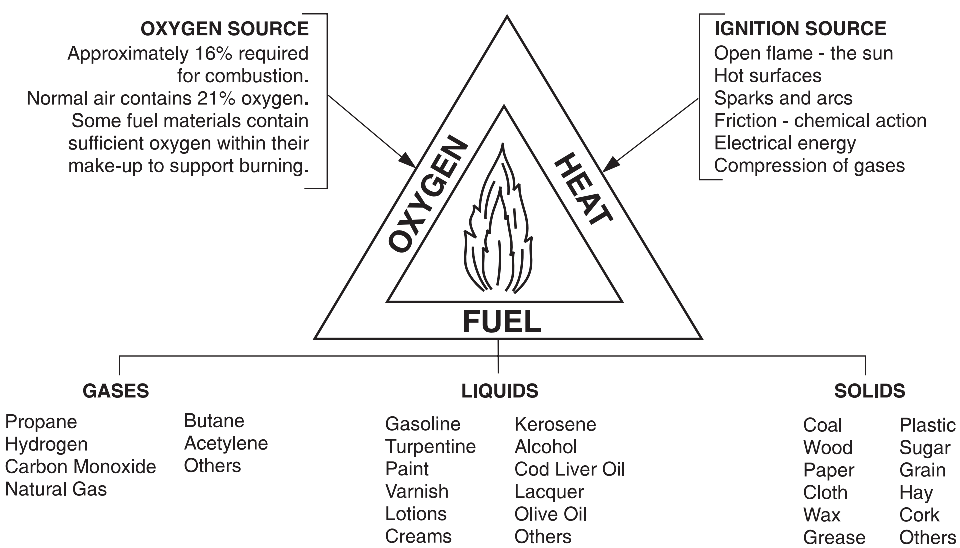


Figure 1-6: Combustion Triangle

1.4 LIQUID OXYGEN SATURATION PRINCIPLES

Oxygen, in its normal state, is a colorless, tasteless, and odorless gas that is non-flammable, although it greatly accelerates combustion in high concentrations. It constitutes about 21% of the Earth's atmosphere by volume. Oxygen in higher concentrations is medically beneficial to patients suffering from certain respiratory diseases.

Oxygen, like most gases, will condense into a liquid with an increase in pressure or decrease in temperature. As a liquid, oxygen is pale blue in color and is about 860 times as dense as its gaseous form. At atmospheric pressure (14.7 psia), oxygen condenses into its liquid form at a temperature of about -297°F (-184°C). Liquid oxygen (LOX) is an efficient form of oxygen to meet a patient's portable, ambulatory oxygen needs. A volume of liquid oxygen, when vaporized, yields about 860 volumes of gaseous oxygen (Figure 1-5). As you can see, a relatively small volume of liquid oxygen provides a much larger volume of gaseous oxygen for a patient to use.

In medical liquid oxygen systems, liquid oxygen, and the gaseous oxygen resulting from its vaporization or boiling, is stored under pressure. The elevated pressure, typically 22 psig (152 kPa), enables oxygen to flow to the patient at a selected, prescribed rate. To sustain this oxygen flow to the patient, the liquid oxygen must be in a state that allows vaporization to readily occur. In other words, the liquid oxygen must be in a state of saturation. Let's take a look at what liquid saturation is all about.

A saturated liquid is one that absorbs the maximum amount of heat possible at a given pressure without vaporizing into a gas. If additional heat is added, the saturated liquid begins to vaporize (boil) while remaining at a constant temperature until all of the liquid is vaporized. A common example of a saturated liquid is water at its boiling point of 212°F (100°C) at sea level. The constant addition of heat to the boiling water does not cause it to become hotter, but instead causes part of the liquid water to turn to water vapor (Figure 1-7).

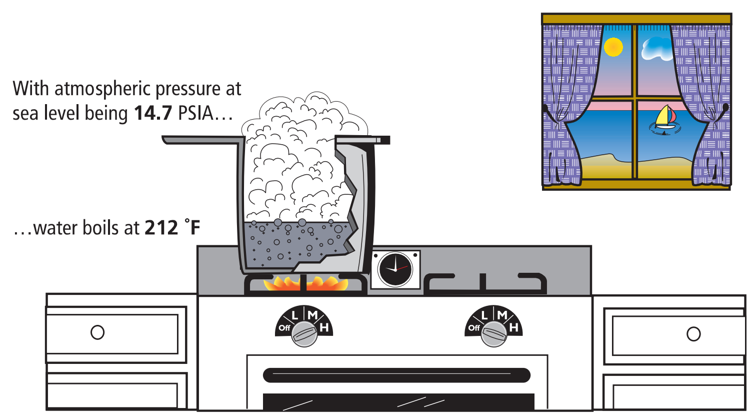


Figure 1-7: Saturated (Boiling) Water at Sea Level

The saturation (boiling) point of a liquid depends not only on temperature but also on pressure. If the **pressure** in a container of saturated liquid **increases**, the **temperature** required for saturation to occur will also **increase**. This leaves the liquid unsaturated, that is, capable of accepting more heat before it will boil (Figure 1-8).

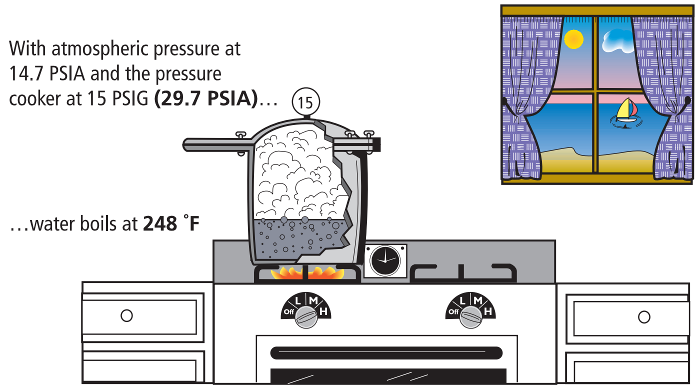


Figure 1-8: Saturated (Boiling) Water at Higher Pressure

If the **pressure** in a container of saturated liquid **decreases**, the **temperature** required for saturation to occur will **decrease**. This leaves the liquid "super saturated" or too warm. When this occurs, rapid boiling and vaporizing of some of the liquid occurs. The rapid boiling and evaporation of the liquid dissipates the excessive heat until the remaining liquid cools down to the new saturation temperature associated with the decreased pressure (Figure 1-9).

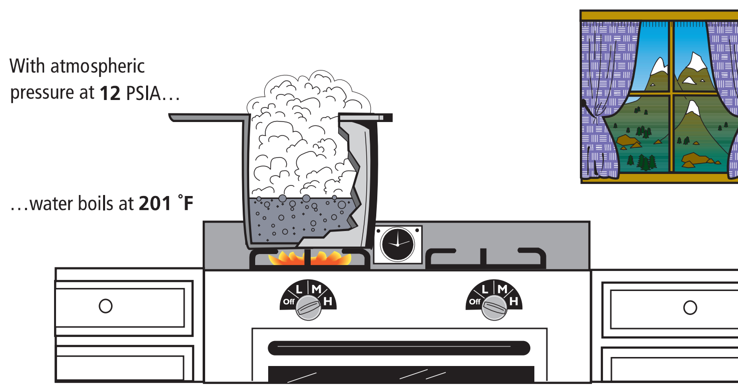


Figure 1-9: Saturated (Boiling) Water at Lower Pressure

Oxygen, which is normally a gas at atmospheric pressure, changes into liquid form when it is cooled to about -297°F (-183°C) at atmospheric pressure. It is saturated at this temperature (and pressure) which means it will remain a liquid as long as no additional heat is added. However, the large quantity of heat present in the atmosphere constantly enters the liquid oxygen and causes it to boil and vaporize back into a gas. Since it is virtually impossible to keep all of the heat in the atmosphere from entering the liquid oxygen, constant boiling and vaporization occurs.

Now when liquid oxygen is placed in a closed container, the vaporizing gas is trapped and begins to build pressure. As pressure increases above atmospheric pressure, more heat is needed for boiling to occur at the higher pressure. The heat that is constantly available from the atmosphere warms the liquid to a higher temperature where boiling again occurs. The vaporizing gas builds pressure and the process continues. As the pressure on liquid oxygen builds, the related saturation temperature of the liquid increases proportionally (Figure 1-10).

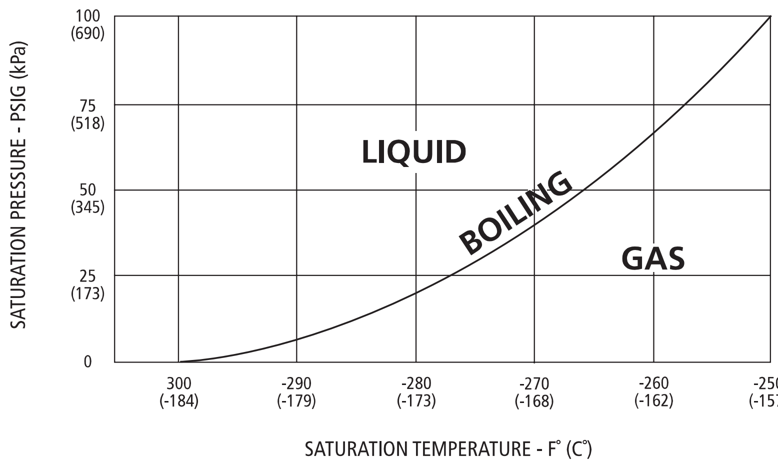


Figure 1-10: Liquid Oxygen Saturation Curve

It is important to maintain liquid oxygen saturation (boiling) at the specified operating pressure of the HELiOS system. As an oxygen flow demand is put on the system, a slight decrease in pressure occurs due to oxygen withdrawal. The saturated liquid oxygen in the system vaporizes enough gaseous oxygen to maintain system operating pressure. This ensures proper oxygen flow to the patient. If the liquid oxygen saturation temperature is too low, the corresponding lower saturation pressure causes low oxygen flows to the patient.

1.5 PRESSURE FITTINGS AND CONNECTIONS

The HELiOS liquid oxygen system uses aluminum tubing compression fittings, tapered pipe thread (NPT) fittings, and flexible tube barbed fittings. Proper make-up and service of these pressure fittings is essential to leak-free operation.

1.5.1 Compression Fitting Makeup

The compression fittings used in the HELiOS system consist of a fitting body, tube, ferrule, and nut (Figure 1-11). These fittings typically connect the aluminum tubing to other components in the system. In a properly made-up compression fitting, sealing occurs at two points: between the ferrule and the fitting body; and between the ferrule and the tube.

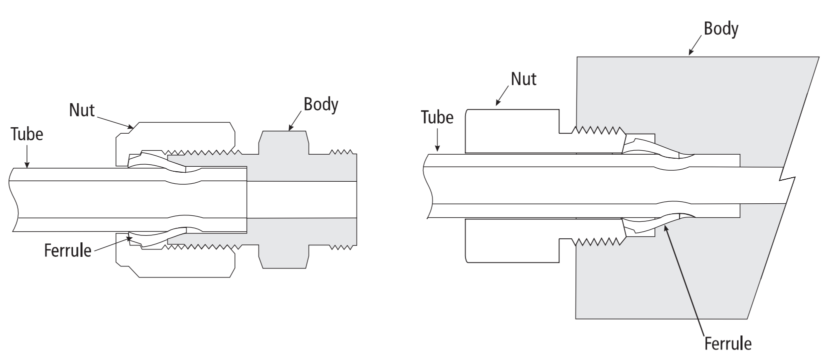


Figure 1-11: Compression Fitting

Perform the following steps to make up a new compression fitting:

1. Inspect the tube end. The tube end should be cut square and the outside surface of the tube should be free of scratches or other marks at least one inch (25 mm) back from the tube end. Lightly buff the tube end with Scotch-Brite or fine emery paper to remove any surface marks.
2. Insert the tube and make sure it is aligned squarely in the fitting body.
3. Make sure the tube end is bottomed against the tube stop in the fitting body. This is necessary to prevent movement of the tube while the nut forces the ferrule to grip the tube and create a seal.
4. Never permit the fitting body to rotate during make-up; use two wrenches. Always hold the fitting body with a wrench while tightening the tube nut.
5. Always turn the tube nut the prescribed amount. With the tube against the tube stop in the fitting body, tighten the tube nut finger-tight (Figure 1-12). For ¼-in. diameter tubing, tighten the nut an additional 1¼ turns from finger-tight with a wrench. For 1/8-in. diameter tubing, tighten the nut an additional ¾ turn from finger-tight with a wrench.

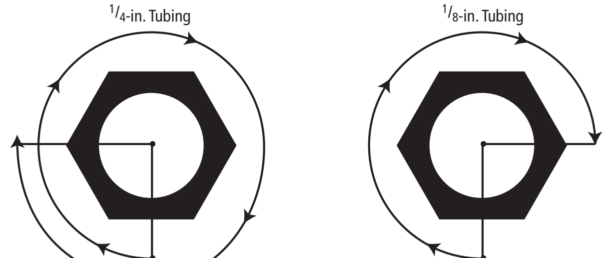


Figure 1-12: Compression Fitting Makeup

1.5.2 Compression Fitting Remake

When disassembling a compression fitting, mark the tube nut and the fitting body before disassembly. To remake the connection, tighten the tube nut until the marks realign. A slight torque increase indicates the ferrule is being re-sprung into sealing position. After several remakes, it may become necessary to advance the tube nut slightly past the original position. This advance need only be 15° to 20° (¼ to 1/3 of a hex flat). In situations where the existing tube with seated ferrule is to be used with a replacement fitting body, tighten the tube nut until a slight torque increase indicates the ferrule is being re-sprung into sealing position. Advance the nut an additional 15° to 20°.

1.5.3 Compression Fitting Troubleshooting

Most leaks in compression fittings are the result of improper connections. Typically the tube is either not aligned squarely in the fitting body before connection or the tube is not secured against the stop during connection. In addition, overtightening may also result in a cracked fitting body that will leak.

To check for leaks, pressurize the system and use an oxygen-compatible leak detector (such as SNOOP) on the fitting. If bubbles form at the back of the nut between the nut and the tube, you probably did not get a seal between the ferrule and the tube; misalignment may be the cause. However, check the tube itself for a scratch or seam running along the tube, allowing a leak to occur.

If the leak detector forms bubbles at the front of the nut, between it and the fitting body, then the leak is probably between the ferrule and the fitting's tapered seat. Check this area for imbedded dirt or cracks.

1.5.4 Tapered Pipe Thread (NPT) Makeup

Some components used in the HELiOS system have tapered pipe (NPT) threads (Figure 1-13). NPT threads create leak-tight connections provided a thread sealant (such as Teflon tape) is used on the threads.

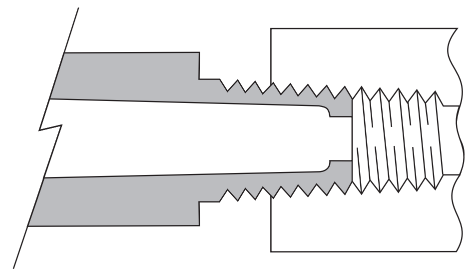


Figure 1-13: NPT Fittings (National Pipe Tapered)

Perform the following steps when making up a NPT fitting:

1. Remove old thread sealant if present. Use a wire brush to remove sealant or dirt from male and female threads of NPT fittings. Make sure contaminants do not drop into the fittings during the cleaning process.
2. Apply thread sealant to the male threads. Apply two to three layers of Teflon tape to the male threads starting two threads back from the end (Figure 1-14). Wrap the Teflon tape clockwise (as viewed from thread end of fitting) to prevent unraveling when installing the fitting.

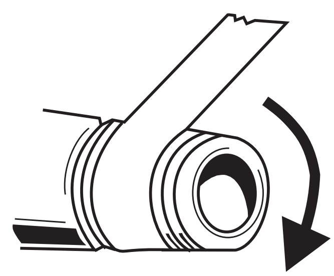


Figure 1-14: Applying Teflon Tape

3. Assemble the fittings and tighten until snug. Since NPT fittings have tapered threads, torque requirements increase as the fittings are tightened. Tighten NPT fittings until you achieve a good seal (usually a minimum of three turns). Do not overtighten NPT fittings. Overtightening may result in cracked fittings.

Note: Some NPT connections require alignment of one of the fittings in a certain orientation. Do not back out the fitting if you are unable to achieve the proper orientation as you tighten the fitting. This will typically result in a leak. Disassemble and remake the fittings instead.

1.5.5 Tapered Pipe Thread Troubleshooting

Leaks at NPT fittings are usually the result of improper application of thread sealant or loosening of the fittings. To check for leaks, pressurize the system and use an oxygen-compatible leak detector (such as SNOOP) on the fitting threads. If bubbles appear, disassemble the fittings and remake (Section 1.5.4, Tapered Pipe Thread Makeup).

1.5.6 Flexible Tube Barbed Fitting Makeup

Flexible tube barbed fittings are used in the HELiOS system to create leak-tight pressure connections where flexible tubes connect to components. The outside diameter of the barb is slightly larger than the inside diameter of the flexible tubing. This creates an interference fit sufficient to seal and secure the connection.

Perform the following steps to install a flexible tube on a barbed fitting:

1. Inspect the tube end. The tube end should be cut square and should be free of cuts or tears. If there is an impression of the barb in the tube, cut the end of the tube off (if the tube length is sufficient) or replace the tube.

2. Where required, install a brass collar on the tube so that the large end of the collar is toward the barbed fitting.

3. Push the tube squarely onto the barb as far as possible.

4. Push the brass collar (if present) onto the tube end connected to the barbed fitting.

1.5.7 Flexible Tube Removal from Barbed Fitting

Perform the following steps to remove the flexible tube from a barbed fitting:

1. Use a small flat-blade screwdriver to carefully back the brass collar (when used) off of the barbed fitting.

2. Work the screwdriver between the end of the tube and the fitting body.

3. Simultaneously pull on the tube and pry the end of the tube back from the barb. Use care to prevent damage to the barbed fittings.

1.6 RECOMMENDED TOOLS, TEST EQUIPMENT, AND SERVICE MATERIALS

Hand tools, test equipment, and materials used to properly service the HELiOS system and maintain it in operable condition are listed in Table 1-1. If hand tools, test equipment, and materials other than those specified in Table 1-1 are used, their functional characteristics such as quality and accuracy must be equal to, or better than, those specified in the table. Tools, test equipment, and materials should be cleaned for oxygen service.

TABLE 1-1. RECOMMENDED TOOLS, TEST EQUIPMENT & SERVICE MATERIALS

TOOLS

Hex Key (Allen) Wrench – 3/32 in., 7/64 in., 5/32 in.	Local Source
Open End Wrenches – ¼ in., ½ in., 9/16 in., 5/8 in., ¾ in., 7/8 in., 1 in.	Local Source
Adjustable Wrench – 10 in.	Local Source
Pliers – 10 in. arc-joint, needlenose	Local Source
Screwdrivers – medium flat blade, small flat blade, medium Phillips blade, Torx T 10	Local Source
Side Cutters	Local Source
Vent Wrench (Figure 1-15)	Puritan-Bennett No. B-775182-00
PB Fill Connector Cartridge Installation Tools (Figure 1-16) • Inner Plunger • Male Connector Sleeve • Female Connector Sleeve	 Puritan-Bennett No. B-775392-00 Puritan-Bennett No. B-775393-00 Puritan-Bennett No. B-775394-00
Micro Bar Clamp	American Tool 6-in. Quick-Grip #53006
Clamp or Hemostat for 1/16 in. Flexible Tubing	Local Source
Dental Pick	Local Source

TEST EQUIPMENT

Portable Test Fixture (Figure 1-17)	Puritan-Bennett No. B-778202-00
Test Pressure Gauge w/Tubing Adapter – 0-100 psig/0-690 kPa (Figure 1-18)	Puritan-Bennett No. B-701732-00
Reservoir Pressurizing Fixture – 0-100 psig/0-690 kPa (Figure 1-19)	Puritan-Bennett No. B-701731-00
HELiOS Reservoir Unit w/Liquid Oxygen Saturation at 24 psig (166 kPa) minimum (for Portable testing)	Puritan-Bennett No. B-701652-00 or Puritan-Bennett No. B-701653-00
Adjustable 0-100 psig (0-690 kPa) gaseous oxygen source	Local Source
Oxygen Compatible Leak Detector (Snoop)	Puritan-Bennett No. B-775272-00
Calibrated Weight Scale – 0-200 lbs (0-91 kg) with .02 lb (9.1 g) maximum graduation, accuracy, and repeatability	A&D Engineering Model FW 100-KA1 (or equivalent)
Calibrated Test Flowmeters • 0-3 L/min oxygen, 1% full scale • 0-40 L/min oxygen, 1% full scale	Brooks Instrument Division, Emerson Electric Co., Hatfield, PA
0-10 L/min, 22 psig external flow control valve	Puritan-Bennett No. B-701655-00

OPTIONAL (PORTABLE ONLY)	
Magnehelic Gauge Assembly – 0-25 in. H2O (Figure 1-20)	Puritan-Bennett No. B-778208-00
Jet/Venturi Assembly (Figure 1-21)	Puritan-Bennett No. B-778210-00
Jet/Venturi	Puritan-Bennett No. B-778213-00

SERVICE MATERIALS	
Dual Lumen Cannula (Portable)	Puritan-Bennett No. B-778057-00 (7 ft./2.1 m)
Oxygen DISS Wye Outlet Adapter w/ Demand Check Valve Outlets	Bay Corp., Westlake, OH-Part No. YO-124DV; Precision Medical, Inc., Northhampton, PA-Part No. 7211
Size 00 Rubber Stopper	VWR Scientific, Batavia, IL-Part No. 59590-084
Tee Connector – 3/16 in. I.D. Tubing	Puritan-Bennett No. B-778211-00
3/16 in. (5 mm) I.D. Oxygen Tubing	Puritan-Bennett No. B-778214-00 (4 ft./1.2 m)
Tie Wrap, 4-in./10 cm	Puritan-Bennett No. B-775091-00
Lubricant - Krytox 240 AC Fluorinated Grease (DuPont)	Puritan-Bennett No. B-775239-00
Isopropyl Alcohol	Local Source
Thread Sealant – 3/16 in. Teflon Tape	Local Source
Cloth – Lint Free	Local Source
HELiOS Oxygen Supply Tube Coupler	Puritan-Bennett No. B-701686-00

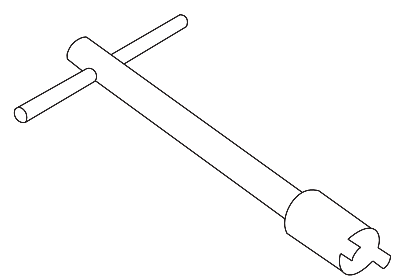


Figure 1-15: Vent Wrench
B-775182-00

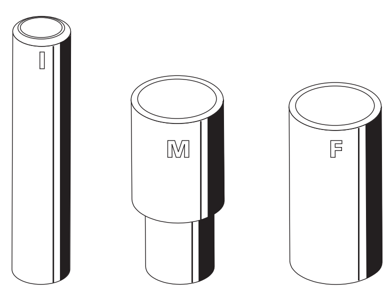


Figure 1-16: Fill Connector Cartridge Installation Tools
B-775392-00 (I), B-775393-00 (M), B-775394-00 (F)

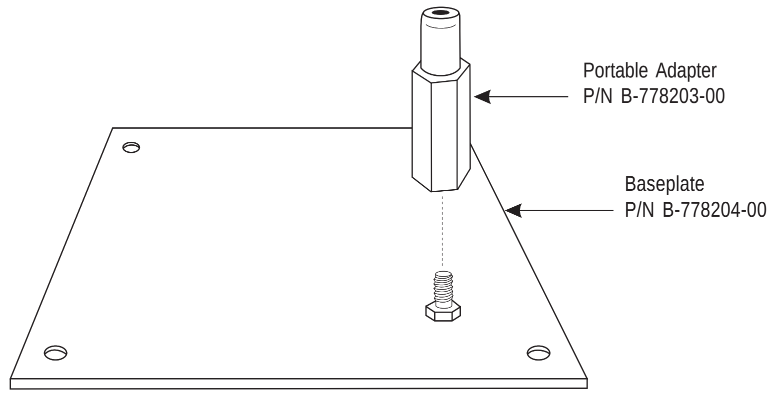


Figure 1-17: Portable Test Fixture B-778202-00

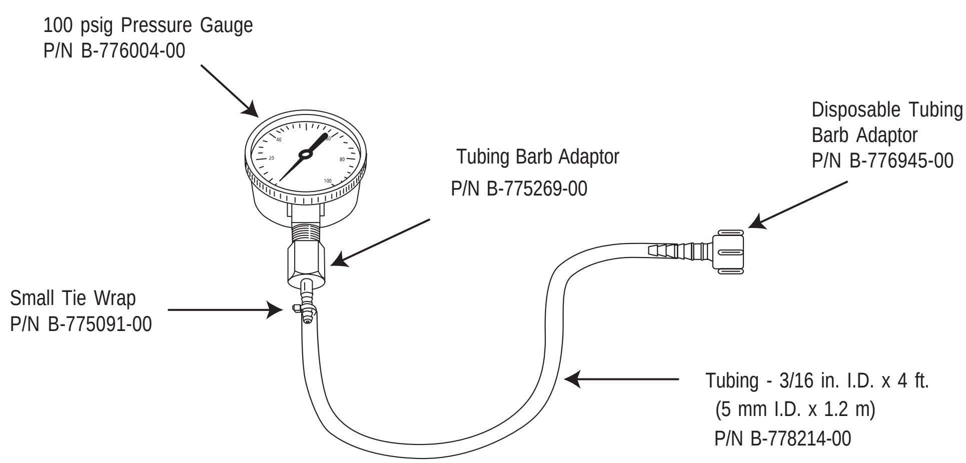


Figure 1-18: Test Pressure Gauge w/Tubing Adapter B-701732-00

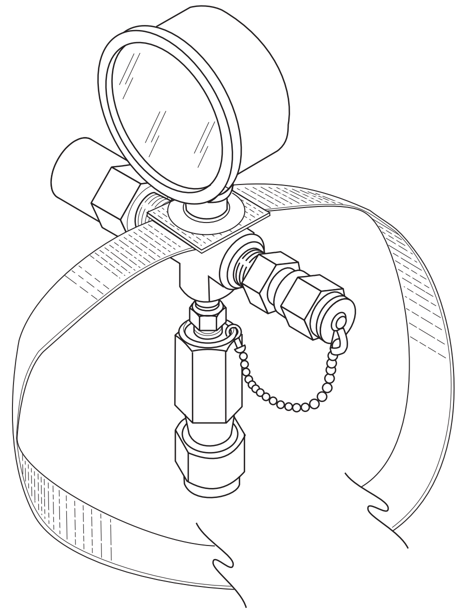


Figure 1-19: Reservoir Pressurizing Fixture
B-701731-00

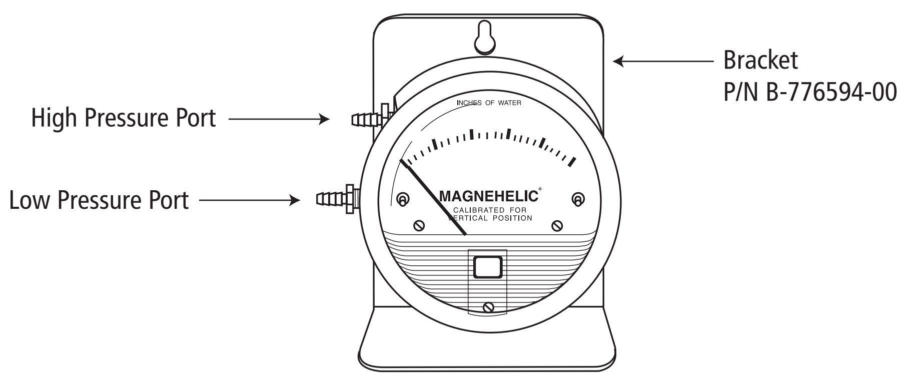


Figure 1-20: Magnehelic Gauge Assembly
B-778208-00

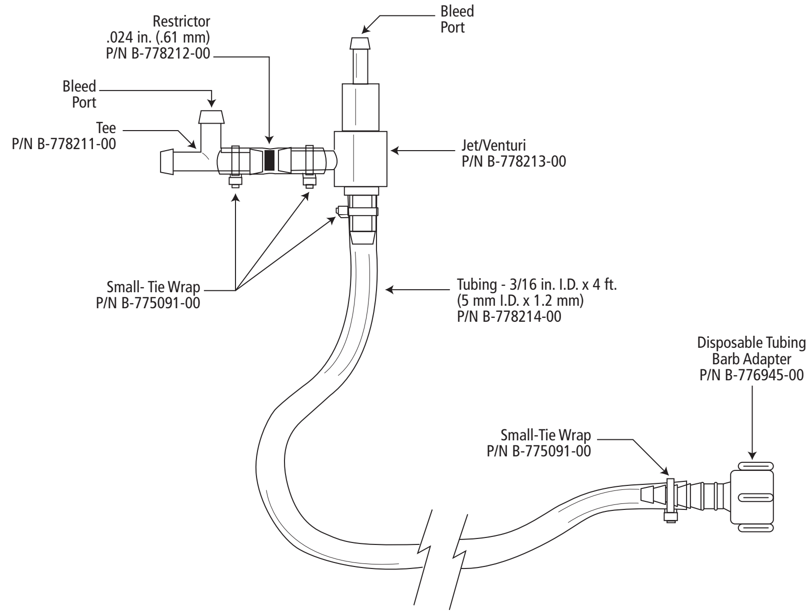


Figure 1-21: Jet/Venturi Assembly
B-778210-00

1.7 TEST EQUIPMENT CALIBRATION

Periodically calibrate test equipment (pressure gauges, weight scales, flowmeters, etc.) to ensure the reliable operation of the HELiOS liquid oxygen system. Use your prior experience to determine calibration frequency for test equipment. Using a default six-month schedule is typically acceptable; however, check test equipment with a high usage rate once a month. Once you have begun using the piece of test equipment, you may adjust the calibration schedule. If, for example, you begin calibrating your test pressure gauge every six months and it is repeatedly out of calibration when you check it, you should test calibration more frequently. Eventually, you should determine an interval where your equipment is in calibration each time you check it.

Before using any piece of test equipment that has been dropped or mishandled, always perform a calibration check. Test instruments that are used to test the performance of HELiOS equipment can be sent to an accredited calibration lab for calibration testing. Another option is to keep a calibrated master test instrument (pressure gauge, flowmeter, etc.) on site as a reference to check your field test instruments. Look in the telephone yellow pages under *Calibration* for the location of an accredited calibration lab. An example of an accredited calibration lab is:

PTS Calibrations LLC, 5603 W. Raymond St., Suite 1, Indianapolis, IN 46241
Telephone: 317-487-2378

Refer to ISO 10012-1 (Quality Assurance Requirements for Measuring Equipment) for additional information.

1.8 ACCESSORIES

Accessories for the HELiOS Reservoir and Portable units are listed in Table 1-2.

Table 1-2

HELiOS ACCESSORIES

Description	Part Number	Location
1. Van Companion Assembly (Delivery Cart)	B-775462-00	Figure 1-22
• Strap and Buckle Assembly	B-775477-00	Figure 1-22, #1
• Faspin	B-775478-00	Figure 1-22, #2
• Pads (2 Required)	B-775476-00	Figure 1-22, #3
• Wear Strips (2 Required)	B-776169-00	Figure 1-22, #4
2. Roller base Assembly	B-701537-00	Figure 1-23
• Caster (5 Required)	B-701536-00	Figure 1-23, #1
3. Transfer Line Assembly (6 ft./1.8 m)	B-775288-00	Figure 1-24
Transfer Line Assembly (10 ft./3 m)	B-775289-00	Figure 1-24
• Transfer Hose (6 ft./1.8 m)	B-775280-00	Figure 1-24, #1
• Transfer Hose (10 ft./3 m)	B-775281-00	Figure 1-24, #1
• Source Adapter Assembly	B-775279-00	Figure 1-24, #2
• Relief Valve (150 psi/1035 kPa)	B-775273-00	Figure 1-24, #3
• Source Adapter	B-775313-00	Figure 1-24, #4
• Fill Adapter Assembly	B-775278-00	Figure 1-24, #5
• Fill Adapter	B-775312-00	Figure 1-24, #6
• Fill Adapter Seal	B-775262-00	Figure 1-24, #7
• Female Fill Connector	B-775264-00	Figure 1-24, #8
• Union, 5/8-in. Flare (2/Transfer Line)	B-775277-00	Figure 1-24, #9
4. Universal Adapter Kit	B-775461-00	Figure 1-25
• Male Flare Adapter	B-775342-00	Figure 1-25, #1
• Female Flare Adapter	B-775418-00	Figure 1-25, #2
• PB Fill Connector/Tee Assembly	B-775276-00	Figure 1-25, #3

Table 1-2 (cont.)

HELiOS ACCESSORIES		
Description	**Part Number**	**Location**
5. Shipping Carton, HELiOS 36	B-701690-00	Not Shown
• Corner Post (4 Required)	B-702011-00	Not Shown
Shipping Carton, HELiOS 46	B-701691-00	Not Shown
• Corner Post (4 Required)	B-702011-00	Not Shown
Shipping Carton, HELiOS 300 Portable	B-701688-00	Not Shown
• Insert (1 Required)	B-701689-00	Not Shown
6. Dual Lumen Cannula (7 ft./2.1 m) (Sense and delivery in both nostrils)	B-778057-00	Figure 1-26
Dual Lumen Cannula (5 ft./1.5 m) (Sense and delivery in both nostrils)	6-778058-00	Figure 1-26
Dual Lumen Cannula (3 ft./0.9 m) (Sense and delivery in both nostrils)	B-701511-00	Figure 1-26
Dual Lumen Cannula (7 ft./2.1 m) (Sense and delivery in separate nostrils)	B-701930-00	Figure 1-26
Dual Lumen Cannula (4 ft./1.2 m) (Sense and delivery in separate nostrils)	B-701931-00	Figure 1-26
7. Oxygen Supply Tube Assy. (50 ft./15.2 m)	B-701656-00	Figure 1-27
8. Oxygen Supply Extension Tube (50 ft./15.2 m)	B-701432-00	Not Shown
9. Reservoir Fill Connector Cover	B-777095-00	Figure 1-28
10. H-300 Portable Belt Pack	B-701654-00	Not Shown
11. HELiOS Operating Instructions	B-701641-00	Not Shown
12. 0-10 L/min Flow Control Valve, 22 PSI (152 kPa)	B-701655-00	Not Shown

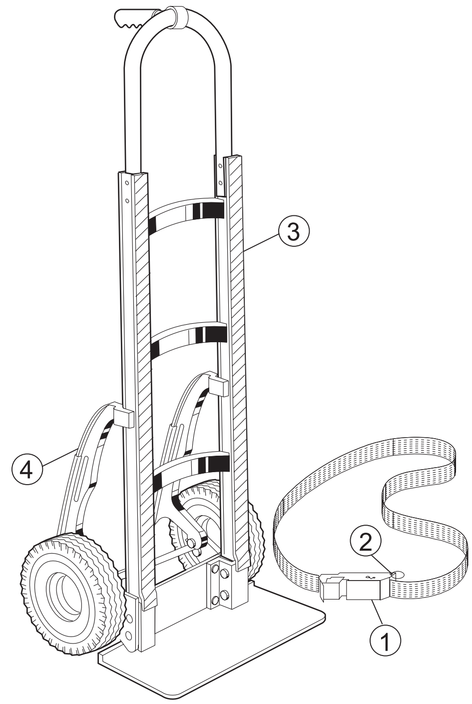


Figure 1-22: Van Companion Delivery Cart

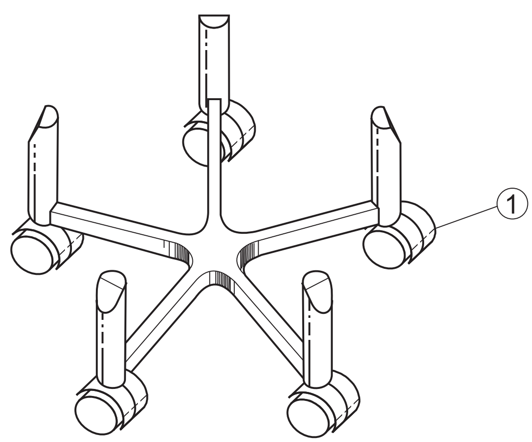


Figure 1-23: Roller Base

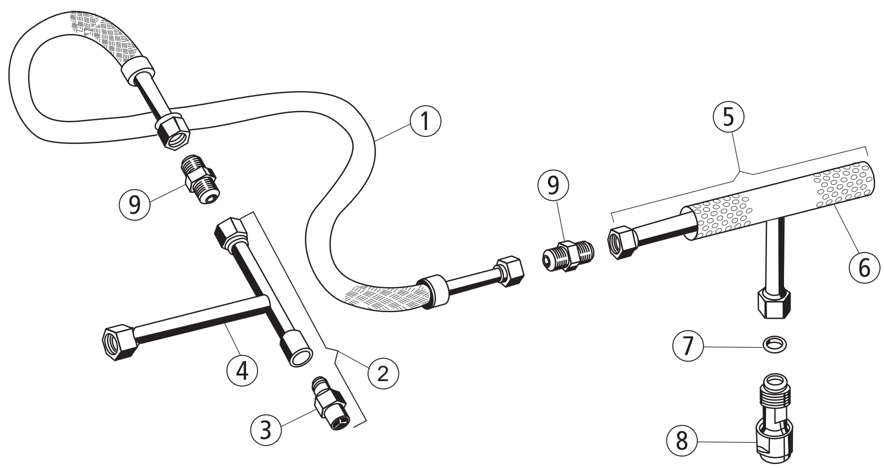
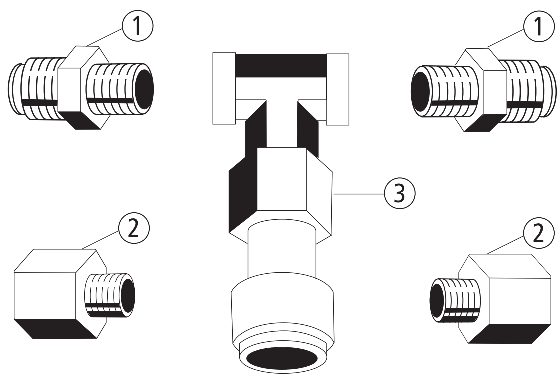


Figure 1-24: Transfer Line Assembly



NOTE: Install the universal adapter kit on the transfer line assembly to allow the filling of both Puritan-Bennett and liquid oxygen units with side-fill connectors with the same transfer line. (Installs between the side-fill adapter and the transfer hose.)

Figure 1-25: Universal Adapter Kit

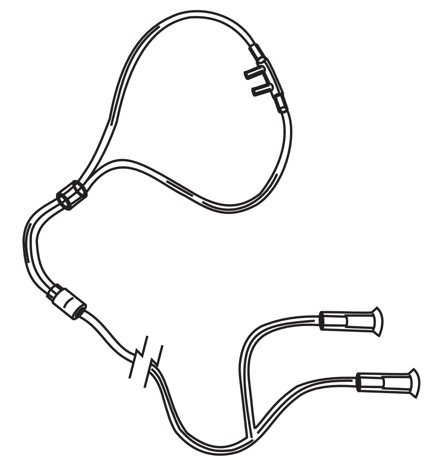


Figure 1-26: Dual Lumen Cannula

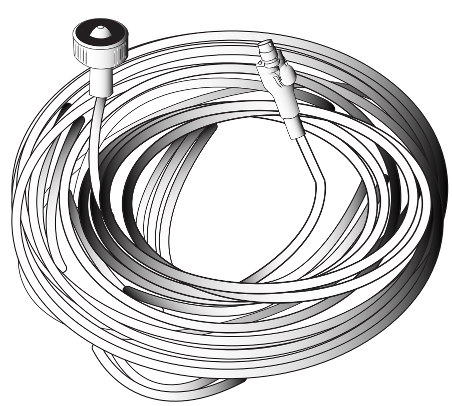


Figure 1-27: Oxygen Supply Tube

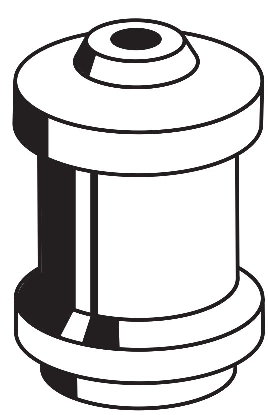


Figure 1-28: Reservoir Fill Connector Cover

Section 2

RESERVOIR GENERAL INFORMATION

This section provides general information on the HELiOS Reservoir liquid oxygen system (Figure 2-1). This information includes a product description; performance specifications; unpacking, installation, and repacking procedures; description of controls, indicators, and connectors; filling instructions; operating procedures; and maintenance.

H-46, U-46 ***H-36, U-36***

Figure 2-1: HELiOS Reservoir Units

2.1 PRODUCT DESCRIPTION

2.1.1 HELiOS Standard Reservoir

The HELiOS Standard Reservoir is part of an innovative liquid oxygen system that provides 24 hour per day home oxygen therapy with typically less than one liquid oxygen delivery per month. The Reservoir provides the patient with a source of liquid oxygen to fill any HELiOS Portable for ambulatory use and a source of gaseous oxygen to power the HELiOS 300 Portable at home. The unique design of the Reservoir virtually eliminates oxygen evaporative losses both in standby mode and when supplying gaseous oxygen to a patient. The Reservoir is available in two models that are nearly identical with the exception of the liquid oxygen storage capacity. The H-36 holds 36 liters (85 lbs/38.6 kg) of liquid oxygen while the H-46 holds 46 liters (110 lbs/49.9 kg) of liquid oxygen.

The Reservoir uses the popular Puritan Bennett top fill connector and is compatible with Puritan Bennett Companion filling equipment (vent wrench, transfer hose assembly, source tank). The Reservoir requires a minimum 24 psig (166 kPa) saturated liquid oxygen to operate and may be filled using standard or fast fill techniques. A standard integral pressure indicator on the unit helps the filling technician maintain proper liquid oxygen saturation pressure during the fill. An electronic contents indicator uses reliable, differential pressure based level sensing technology to provide accurate and easy to read liquid oxygen contents indication. The 9-volt battery powered contents indicator incorporates

high visibility LEDs for indicating liquid oxygen contents. LEDs also warn of low battery and low contents conditions.

The Reservoir provides 22 psig (152 kPa) gaseous oxygen at up to 10 L/min continuous flow through a Diameter Index Safety System (DISS) connection. Oxygen outlet pressure is regulated at 22 psig (152 kPa) since the unique design of the Reservoir allows internal pressure to climb as high as 45 psig (311 kPa) in standby. A flexible oxygen supply tube, attached to the outlet connector, provides gaseous oxygen to power the H-300 Portable. To fill a HELiOS Portable with liquid oxygen, the patient merely engages the quick connect couplings on the Portable and Reservoir. The patient then opens the Portable vent valve to begin filling and closes the vent valve a short time later to terminate the fill. Reservoir pressure transfers slightly less than one pound of liquid oxygen into an H-300 Portable. Depressing a release button disengages the Portable from the Reservoir. **Due to different operational specifications, Puritan Bennett Companion system portables cannot be filled from the HELiOS Standard Reservoir.**

For a more technical description of how the Reservoir operates, refer to Section 3, Theory of Operation.

2.1.2 HELiOS Universal Reservoir

The HELiOS Universal Reservoir retains many of the features of the Standard Reservoir while being compatible with Companion portable units. The Reservoir provides the patient with a source of liquid oxygen to fill any Companion portable or H300 Portable for ambulatory use and provides a source of gaseous oxygen to power the HELiOS 300 Portable at home. The unique design of the Reservoir minimizes oxygen evaporative losses both in standby mode and when supplying gaseous oxygen to a patient. The Reservoir is available in two models that are nearly identical with the exception of the liquid oxygen storage capacity. The U-36 holds 36 liters (85 lbs/38.6 kg) of liquid oxygen while the U-46 holds 46 liters (110 lbs/49.9 kg) of liquid oxygen.

The Reservoir uses the popular Puritan Bennett top fill connector and is compatible with Puritan Bennett Companion filling equipment (vent wrench, transfer hose assembly, source tank) and Companion portables. The Reservoir requires a minimum 22 psig (152 kPa) saturated liquid oxygen to operate and may be filled using standard or fast fill techniques. An electronic contents indicator uses reliable, differential pressure based level sensing technology to provide accurate and easy to read liquid oxygen contents indication. The 9-volt battery powered contents indicator incorporates high visibility LEDs for indicating liquid oxygen contents. LEDs also warn of low battery and low contents conditions.

The Reservoir provides 22 psig (152 kPa) gaseous oxygen at up to 10 L/min continuous flow through a Diameter Index Safety System (DISS) connection. Unlike the Standard Reservoir, the Universal Reservoir oxygen outlet pressure is maintained at 22 psig (152 kPa) when a flow is delivered but climbs to 26 psig (179 kPa) when in standby mode. A flexible oxygen supply tube, attached to the outlet connector, provides gaseous oxygen to power the H-300 Portable. To fill a HELiOS or Companion portable with liquid oxygen, the patient merely engages the quick connect couplings on the portable and Reservoir. The patient then opens the portable vent valve to begin filling and closes the vent valve a short time later to terminate the fill. Depressing a release button disengages the portable from the Reservoir.

For a more technical description of how the Reservoir operates, refer to Section 3, Theory of Operation.

2.2 PERFORMANCE SPECIFICATIONS

The HELiOS Reservoir performance specifications are listed below in Table 2-1.

TABLE 2-1

HELiOS RESERVOIR SPECIFICATIONS				
MODEL	**H-36***	**H-46***	**U-36***	**U-46***
Volume of Liquid Oxygen (typical)	36 liters/1.27 ft^3	46 liters/1.62 ft^3	36 liters/1.27 ft^3	46 liters/1.62 ft^3
Weight of Liquid Oxygen at 24 psig (166 kPa) Saturation (typical)	85 lbs/38.6 kg	110 lbs/49.9 kg	85 lbs/38.6 kg	110 lbs/49.9 kg
Gaseous Oxygen Equivalent at 1atm. and 70°F	29,069 liters/1027 ft^3	37,619 liters/1328 ft^3	29,069 liters/1027 ft^3	37,619 liters/1328 ft^3
Height	33.5 in./85.1 cm	37.5 in./95.3 cm	33.5 in./85.1 cm	37.5 in./95.3 cm
Diameter	15.4 in./39.1 cm	15.4 in./39.1 cm	15.4 in./39.1 cm	15.4 in./39.1 cm
Empty Weight	53 lbs/24.0 kg	60 lbs/27.2 kg	53 lbs/24.0 kg	60 lbs/27.2 kg
Full Weight	138 lbs/62.6 kg	170 lbs/77.1 kg	138 lbs/62.6 kg	170 lbs/77.1 kg
Outlet Pressure	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)
Economizer Pressure	27 psig/186 kPa Nominal (Acceptable Range 24.0-30.0 psig/166-207 kPa)	27 psig/186 kPa Nominal (Acceptable Range 24.0-30.0 psig/166-207 kPa)	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.5 psig/141-162 kPa)
Primary Relief Valve Pressure	45 psig/311 kPa Nominal (Acceptable Range 42-48 psig/290-331 kPa)	45 psig/311 kPa Nominal (Acceptable Range 42-48 psig/290-331 kPa)	26 psig/179 kPa Nominal (Acceptable Range 24-28 psig/166-193 kPa)	26 psig/179 kPa Nominal (Acceptable Range 24-28 psig/166-193 kPa)
Secondary Relief Valve Pressure	70 psig/483 kPa Nominal (Acceptable Range 65-75 psig/449-518 kPa)	70 psig/483 kPa Nominal (Acceptable Range 65-75 psig/449-518 kPa)	30 psig/207 kPa Nominal (Acceptable Range 25-37 psig/173-255 kPa)	30 psig/207 kPa Nominal (Acceptable Range 25-37 psig/173-255 kPa)
Normal Evaporation Rate (NER) (typical) (maximum)	1.2 lbs/0.54 kg per Day 1.5 lbs/0.68 kg per Day	1.2 lbs/0.54 kg per Day 1.5 lbs/0.68 kg per Day	1.2 lbs/0.54 kg per Day 1.5 lbs/0.68 kg per Day	1.2 lbs/0.54 kg per Day 1.5 lbs/0.68 kg per Day
Fill Time (standard technique) (fast fill technique)	Warm < 7 min./Cold < 6 min. Warm < 4 min./Cold < 3 min.	Warm < 8 min./Cold < 7 min. Warm < 5 min./Cold < 4 min.	Warm < 7 min./Cold < 6 min. Warm < 4 min./Cold < 3 min.	Warm < 8 min./Cold < 7 min. Warm < 5 min./Cold < 4 min.
Maximum Outlet Flow	10 L/min	10 L/min	10 L/min	10 L/min
Contents Indicator	Electronic, Differential Pressure Based w/Remote Indication Option	Electronic, Differential Pressure Based w/Remote Indication Option	Electronic, Differential Pressure Based w/Remote Indication Option	Electronic, Differential Pressure Based w/Remote Indication Option
Environmental (Operating Temp.) (Storage Temp.)	-20°C to 40°C 95% max. relative humidity -40°C to 70°C 90% max. relative humidity	-20°C to 40°C 95% max. relative humidity -40°C to 70°C 90% max. relative humidity	-20°C to 40°C 95% max. relative humidity -40°C to 70°C 90% max. relative humidity	-20°C to 40°C 95% max. relative humidity -40°C to 70°C 90% max. relative humidity

* Specifications subject to change without notice.

2.3 UNPACKING, INSTALLATION, AND REPACKING

Perform the following procedures when unpacking, installing or repacking a HELiOS Reservoir unit.

2.3.1 Unpacking

1. Examine the shipping carton for damage. If the carton is damaged, or its contents are suspected of being damaged, photograph the damaged carton before the Reservoir is unpacked. Contact the carrier to request a damage inspection. Contact the shipping point immediately.

2. Place the shipping carton on a flat surface with the shipping arrows pointing upwards.

3. Open the top flaps of the shipping carton and remove accessory items.

4. Remove the plastic bag covering the Reservoir and any loose packing inserts.

5. With the assistance of a helper, grasp a handle on the side of the Reservoir. Hold the carton down with one hand and carefully lift the Reservoir up and out of the carton.

6. Compare the packing list attached to the carton's exterior with the shipment received. If any discrepancies exist, contact Puritan-Bennett immediately at 1-800-497-4968.

7. Thoroughly inspect the exterior of the Reservoir for damage (dents, cracks, etc.).

8. Save all packing materials and the shipping carton for reuse.

2.3.2 Installation

Before installing the Reservoir in a patient's home, read and understand Section 2.4, Controls, Indicators, and Connectors; Section 2.5, Filling Instructions; and Section 2.6, Operating Procedures. Perform the following steps upon receipt of shipment:

1. Remove the moisture container and record the Reservoir serial number. Reinstall the moisture container.

2. Verify the fill connector release button and mechanism move freely.

3. Press the button on the contents indicator. Verify that the yellow low contents LED lights.

4. Verify that a Reservoir vent wrench is available for filling the unit.

5. Verify receipt of the HELiOS Operating Instructions (P/N B-701641-00).

6. UNIVERSAL RESERVOIR Verify receipt of the HELiOS Universal Reservoir Reference Guide (P/N B-702125-00).

2.3.3 Repacking for Return

To return a product, contact Puritan-Bennett at 1-800-255-6774 (press 2) and ask to speak with a Technical Support Representative. A Return Goods Authorization (RGA) number will be issued to track the product return. Please have available your account number, the **model and serial number of the product**, and the reason for returning the product when you call to request an RGA. Return the unit in its original carton, if possible. If the original carton is not available, you may purchase a new carton (Section 1.8, Accessories).

WARNING

Fire hazard and extreme cold hazard. Do not package or ship units that contain liquid or gaseous oxygen. Liquid oxygen spillage and high oxygen concentrations are possible. Empty oxygen contents completely before packaging or shipping units. See Section 6.1, Emptying a Reservoir Unit.

1. Obtain the proper carton and inserts for the Reservoir you wish to package (Section 1.8, Accessories).

2. Make sure that the carton inserts are properly in place. The Reservoir handles must engage the inserts.

3. With the assistance of a helper, grasp a handle on the side of the Reservoir and carefully lift the Reservoir up and into the carton. Make sure the inserts snugly support the Reservoir.

4. Fold down the set of carton top flaps that press against the top of the Reservoir. Fold down the second set of flaps and insert the locking tabs into the first set of flaps.

5. Secure the carton with packing tape. Double-tape the carton's bottom seam.

2.4 CONTROLS, INDICATORS, AND CONNECTORS

The controls, indicators, and connectors that are used on the Reservoir unit are shown in Figure 2-2. Their functions are described below.

2.4.1 Fill Connector

The Reservoir uses the top fill Puritan Bennett fill connector to transfer liquid oxygen to and from the unit. It is the male half of a cryogenic quick connect coupling system. A spring loaded poppet automatically opens when the connector is engaged and automatically closes when the connector is disengaged.

2.4.2 Release Button

Pressing the release button on the Reservoir activates the fill connector release lever mechanism. This disengages either a portable oxygen unit or a liquid oxygen transfer line from the Reservoir.

2.4.3 Vent Valve

The vent valve is a quarter-turn ball valve that is accessible with a separate vent wrench through a hole in the Reservoir upper shroud. The filling technician opens the vent valve to vent the inner container during the Reservoir unit filling process. The technician closes the valve upon terminating the filling process.

2.4.4 Pressure Indicator (Standard Reservoir Only)

The pressure indicator displays the status of the pressure inside the Standard Reservoir unit. A filling technician monitors the pressure indicator to help maintain a minimum 24 psig (166 kPa) liquid oxygen saturation pressure in the Reservoir during a fill. Under normal operating conditions, the indicator pointer typically indicates a pressure between 27 psig (186 kPa) and 45 psig (311 kPa). The pressure indicator **does not** indicate the regulated pressure at the Reservoir oxygen outlet.

2.4.5 Contents Indicator

The contents indicator displays the amount of liquid oxygen in the Reservoir. Depressing the button on the contents indicator turns on from one to eight green light emitting diodes (LEDs) that represent the empty to full range of the Reservoir. A yellow “low contents” LED comes on when about 8.5 lbs (3.9 kg) of liquid oxygen remain. A yellow “low battery” LED comes on when battery voltage drops below a predetermined level. A 9-volt alkaline battery powers the contents indicator.

2.4.6 Oxygen Outlet

The Reservoir oxygen outlet provides a source of 22 psig (152 kPa) oxygen at a maximum flow of 10 L/min. A spring activated poppet in the Diameter Index Safety System (DISS) oxygen connector stops oxygen flow when there is nothing attached to the connector. When a HELiOS Portable oxygen supply tube or a flow control device calibrated at 22 psig (152 kPa) is attached to the outlet, the connector poppet opens to allow oxygen to flow.

2.4.7 Moisture Container

The moisture container is part of the Reservoir shroud assembly that collects condensed water run-off from the warming coils. The lower shroud channels the water run-off into the moisture container. The moisture container slides easily out of the lower shroud assembly to be emptied.

FIGURE 2-2: Controls, Indicators, and Connectors

2.5 FILLING INSTRUCTIONS

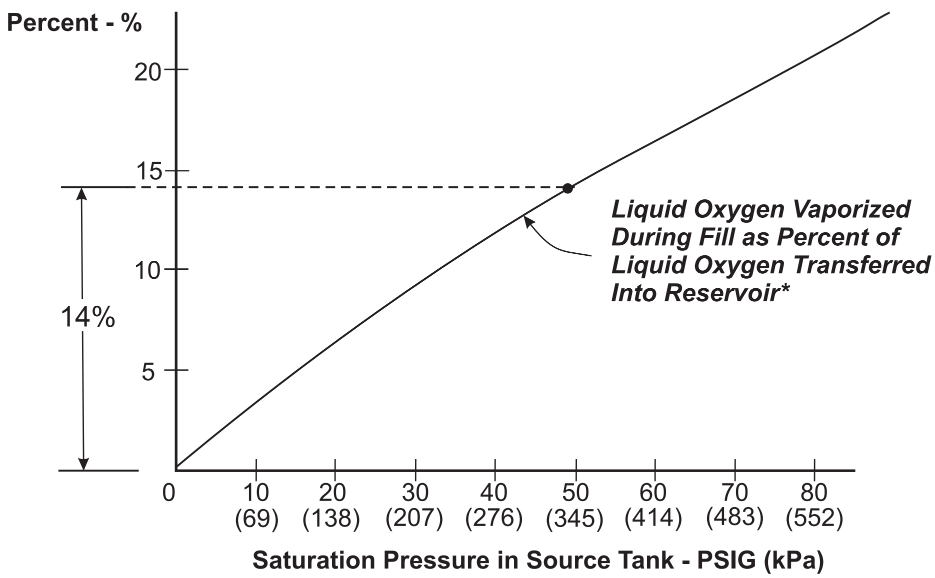
The Reservoir must be filled with liquid oxygen saturated at 24 psig (166 kPa) to ensure proper operation. The information in this section will help you fill the Reservoir with liquid oxygen in a proper, safe, and efficient manner.

2.5.1 Oxygen Source Requirements

The HELiOS Reservoir must be filled with only U.S.P. Medical Oxygen. The liquid oxygen used for filling the Reservoir must have no moisture content. Liquid oxygen entering the Reservoir during the filling operation must be saturated at 24 psig (166 kPa) for proper operation to occur. In order to achieve 24 psig (166 kPa) saturation in the Reservoir during the fill, the saturation pressure of the liquid oxygen filling source must be carefully considered. The filling source saturation pressure requirement mainly depends on the type of filling technique used. The *Standard Fill* technique requires a liquid oxygen source saturation pressure of 40-50 psig (276-345 kPa). The *Fast Fill* filling technique requires a liquid oxygen source saturation pressure of 24-28 psig (166-193 kPa). Following is a brief description of each filling technique and corresponding liquid oxygen source requirement.

Both Reservoir filling techniques use pressure in the source tank as the force to drive the liquid oxygen into the Reservoir. In order to transfer liquid oxygen from the source tank to the Reservoir, a pressure differential must exist so that the source tank pressure remains greater than the Reservoir pressure during the fill. The *Standard Fill* technique requires the source saturation pressure to be greater than the saturation pressure needed in the Reservoir. With the filling source saturated at 40-50 psig (276-345 kPa), the boiling action of the liquid oxygen maintains the pressure differential as the Reservoir pressure is lowered by opening its vent valve. The filling technician adjusts the opening of the

Reservoir vent valve and/or source tank liquid valve to maintain 24 psig (166 kPa) on the Reservoir pressure gauge (internal gauge on standard Reservoir; external gauge connected to oxygen outlet on Universal Reservoir). However, liquid oxygen saturated at 40-50 psig (276-345 kPa) is at a higher temperature than liquid oxygen saturated at 24 psig (166 kPa) (see Figure 1-10, Liquid Oxygen Saturation Curve). During the fill, liquid oxygen saturated at 40-50 psig (276-345 kPa) in the source tank boils rapidly to release heat and cool down to the lower temperature required for 24 psig (166 kPa) saturation in the Reservoir. The rapid boiling (desaturation) of the liquid oxygen creates a large volume of gaseous oxygen that is vented out the Reservoir vent valve during the fill. With the source saturated at 50 psig (345 kPa), a volume of liquid oxygen equal to about 14% of the liquid oxygen transferred into the Reservoir boils off into gas and is expelled through the vent valve as a result of the depressurization (Figure 2-3). Consequently, slower fill times and greater filling losses occur with the *Standard Fill* technique.



Warm Fill, H-46 Reservoir at 25 PSIG (172.5 kPa) Saturation

Figure 2-3: Vapor Release from Depressurized Liquid Oxygen

The *Fast Fill* technique requires the liquid oxygen saturation pressure in the source tank to be about 24-28 psig (166-193 kPa), close to the saturation pressure needed in the Reservoir. With the source saturated at 24-28 psig (166-193 kPa), rapid boiling (desaturation) of the liquid oxygen is minimal as it moves from the source tank into the Reservoir during a fill. However, in order to drive the liquid oxygen from the source tank to the Reservoir, a pressure differential must exist so that the source tank pressure remains greater than the Reservoir pressure during the fill. **Consequently, a source tank equipped with a pressure building circuit must be used with the *Fast Fill* technique.** By turning on the pressure building system in the source tank, a small amount of the liquid oxygen in the tank vaporizes in a heat exchanger and builds pressure above the surface of the liquid oxygen. This provides the head pressure (40-50 psig/276-345 kPa) needed to drive the liquid oxygen saturated at 24-28 psig (166-193 kPa) into the Reservoir. While monitoring the internal pressure gauge (Standard Reservoir) or an external pressure gauge attached to the oxygen outlet fitting (Universal Reservoir), the filling technician adjusts the opening of the Reservoir vent valve and/or source tank liquid valve to maintain 24 psig (166 kPa) saturation in the Reservoir during the fill. Faster fill times and less filling losses are the end results. The *Fast Fill* technique requires a source tank that meets the following conditions:

1. The source tank must be filled with liquid oxygen saturated at 24-28 psig (166-193 kPa).

2. The source tank must be equipped with a 24-28 psig (166-193 kPa) road relief valve, a 40-50 psig (276-345 kPa) pressure building relief valve, and a means to switch between the two relief valves. The 24-28 psig (166-193 kPa) relief valve maintains saturation pressure between fills. The 40-50 psig (276-345 kPa) relief valve enables pressure building to occur during a fill.

3. The source tank must have a pressure building system capable of maintaining 40-50 psig (276-345 kPa) head pressure during each fill.

Since a variety of source tank configurations and filling pressures are possible, contact Puritan-Bennett Technical Support for advice when considering a liquid oxygen source and filling technique to best meet your needs.

2.5.2 Transfer Line

The standard Puritan Bennett transfer line assembly (Figure 2-4) is used to transfer liquid oxygen from the source tank to the Reservoir. The 5/8-in. flared connection on the transfer line source adapter connects to a mating fitting on the source tank liquid withdrawal valve. See Section 1-8, Accessories for individual component descriptions.

WARNING

Explosive hazard. Extreme high pressure can rupture a transfer line. Make sure the specified pressure relief valve is present, in the proper location, and functioning properly.

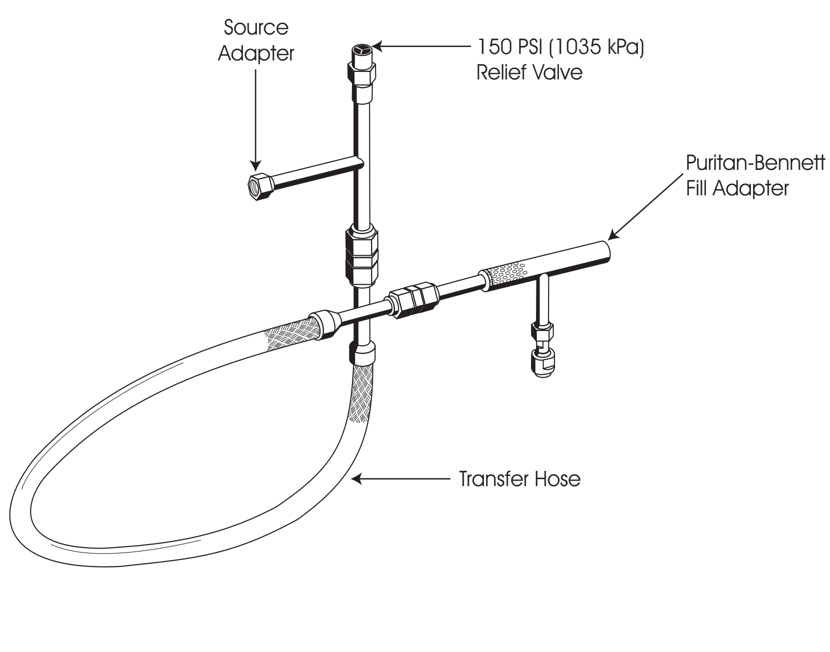


Figure 2-4: Standard Transfer Line Assembly

2.5.3 Pre-Fill Inspection

Perform the following procedure to visually inspect the Reservoir and determine its operational status before filling. Correct observed problems before proceeding to fill the Reservoir.

1. Ask the patient (where applicable) if there are any questions or concerns regarding the equipment since your last visit.
2. Visually inspect the Reservoir unit for overall product integrity (for example, cracked or damaged components).
3. Verify that all labels are present and legible on the unit (Figure 2-5).
4. Verify that no frost or heavy condensation is present on the container below the shroud and that there is no excessive venting from the relief valve. (Some venting from the relief valve is normal.)
5. Verify that the liquid oxygen contents level is consistent with the delivery schedule and expected patient usage.
6. Verify that the fill connector is not worn, leaking, or damaged.
7. Verify that the vent valve stops are not bent or broken.
8. Verify that the contents indicator is operational and at least one green LED or the yellow low contents LED lights when the button is depressed. Replace the 9-volt battery if the yellow low battery LED is on.
9. STANDARD RESERVOIR If the unit contains liquid oxygen, verify that the pressure displayed on the internal pressure indicator is 24-48 psig (166-331 kPa).
   UNIVERSAL RESERVOIR If the unit contains liquid oxygen, connect an external pressure gauge to the oxygen outlet connector and verify that the pressure displayed on the gauge is 20-28 psig (138-193 kPa).
10. Verify that the moisture container is in place and empty.

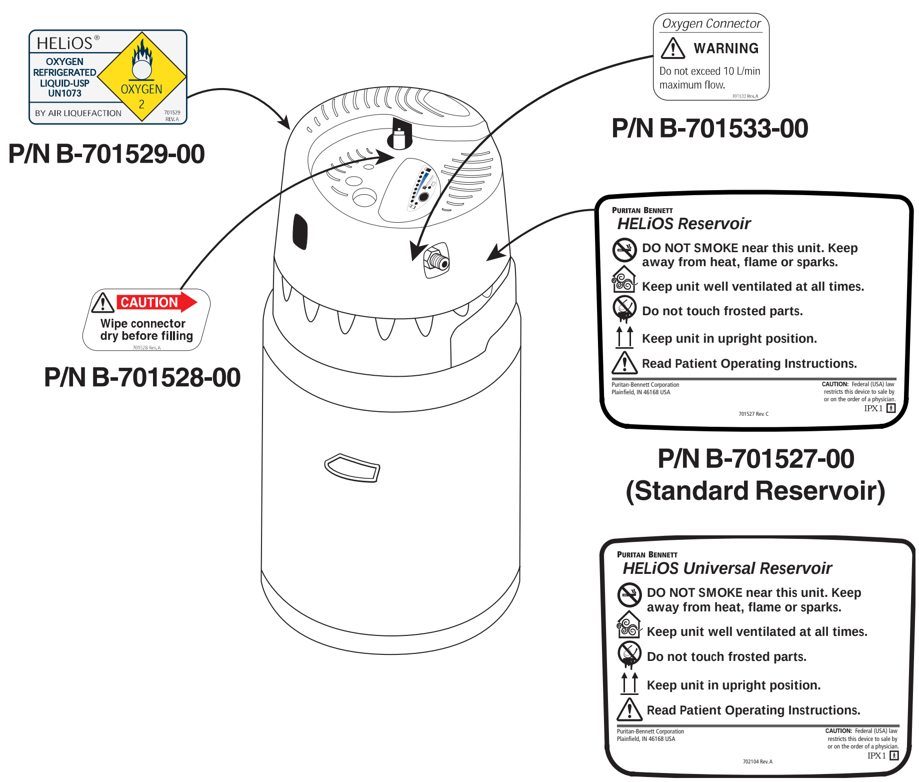


Figure 2-5: Reservoir Labels

P/N B-702104-00
(Universal Reservoir)

2.5.4 Filling Procedure

Perform the following procedure to fill a HELiOS Reservoir with liquid oxygen.

WARNING

Fire hazard. Liquid oxygen spilled on asphalt or any other combustible surface will increase the possibility of fire if an ignition source is present. Always fill the unit on a non-combustible surface, such as concrete or a steel drip pan.

WARNING

Explosive hazard. Extreme high pressure can rupture a transfer line. Make sure the specified pressure relief valve is present, in the proper location, and functioning properly.

WARNING

Fire hazard. Liquid oxygen spillage will occur if the Reservoir is tipped over. Before transporting, secure Reservoir units containing liquid oxygen in an upright position.

WARNING

Fire hazard. Oxygen can accumulate in a delivery vehicle. Exhaust vent gases to outside of vehicle. (See CGA Safety Bulletin SB-9.)

1. Wear the proper protective clothing (Safety Precautions, Section 1.3.1).

2. Verify that the liquid oxygen saturation pressure in the source tank is 40-50 psig (276-345 kPa) if using the *Standard Fill* technique. Verify that the liquid oxygen saturation pressure in the source tank is 24-28 psig (166-193 kPa) if using the *Fast Fill* technique. Refer to Section 2.5.1, Oxygen Source Requirements for more information on source tank requirements.

NOTE: If you experience difficulty obtaining properly saturated oxygen, consult the Technical Service Department (1-800-255-6774, press 2).

3. Attach the 5/8-in. female end of the transfer line source adapter to the liquid withdrawal valve of the source tank. Position the source adapter relief valve straight up.

4. STANDARD RESERVOIR If the Reservoir contains some liquid oxygen, verify that the Reservoir internal pressure gauge reads 24-48 psig (166-331 kPa) (Figure 2-6). A pressure reading outside of this range may indicate a problem. DO NOT attach an external pressure gauge to the oxygen outlet DISS connector. If the unit is empty, continue with step 5 without verifying the pressure at this point.
   UNIVERSAL RESERVOIR Attach an external pressure gauge (P/N B-701732-00 or equivalent) to the Reservoir oxygen outlet DISS connector (Figure 2-7). If the Reservoir contains some liquid oxygen, verify that the external pressure gauge reads 20-28 psig (138-193kPa). A pressure reading outside of this range may indicate a problem. If the unit is empty, continue with step 5 without verifying the pressure at this point.

Internal Pressure Gauge

Figure 2-6: Standard Reservoir

External Pressure Gauge

Figure 2-7: Universal Reservoir

5. Remove the fill connector cover from the fill connector, if present. (Available as an accessory; see Section 1.8, Accessories).

6. Check the fill connectors on both the Reservoir unit and the fill adapter to ensure that they are clean and dry. Wipe the connectors with a clean, lint-free cloth or blow-dry with gaseous oxygen or nitrogen as needed.

7. Use the vent wrench to open the vent valve on the Reservoir unit by rotating the wrench a quarter-turn counterclockwise.

NOTE: At this point you may hear a venting noise if the Reservoir unit is pressurized. Allow the Reservoir pressure to vent down as needed to 24 psig (166 kPa) before engaging the transfer line.

---

8. Engage the transfer line to the fill connector on the Reservoir unit by aligning the fill connector on the transfer line directly over the fill connector on the Reservoir. Apply about 20 lbs (89 n) of downward force.

9. Maintain a downward force on the transfer line fill adapter while slowly opening the liquid valve on the source tank. At this point a vigorous audible venting noise will confirm that the filling process has started. Adjust the source tank liquid valve as needed to **keep the pointer on the pressure gauge at 24 psig (166 kPa).**

NOTE: It may be necessary to open the source tank liquid valve completely and throttle the Reservoir vent valve to maintain the proper pressure during the fill.

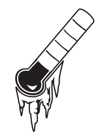
---

10. Close and reopen the vent valve on the Reservoir after 45 to 60 seconds have passed. This will minimize the possibility of the vent valve freezing in the open position.

NOTE: As the level of liquid oxygen nears the top of the Reservoir inner container, the sound and appearance of vapors escaping through the vent valve will change. The vapor will become denser, and as liquid oxygen reaches the vent valve, a discharge of liquid oxygen will be visible and audible.

WARNING

Extreme cold hazard. Liquid oxygen discharge from the fill connector can occur. When disconnecting the transfer line, never stand directly over the Reservoir fill connector. If the Reservoir fill connector stays open and minor liquid oxygen discharge occurs, carefully re-engage and disengage the transfer line to help dislodge any ice or other obstruction. If major liquid oxygen discharge (steady stream) occurs, open the vent valve (if safely possible) to vent pressure and stop the release of liquid oxygen. Open windows and doors to ventilate room and do not walk on areas exposed to liquid oxygen for 60 minutes after frost disappears.



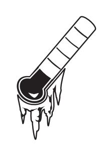
11. When you observe the **first steady discharge** (about 1-2 seconds) of liquid oxygen from the vent valve, disconnect the transfer line from the Reservoir by depressing the portable release button and lifting the fill adapter straight up. Then close the vent valve by rotating the vent wrench a quarter-turn clockwise. If the Reservoir pressure begins to climb past 24 psig (166 kPa), open the vent valve for a few seconds to bring the pressure back down to 24 psig (166 kPa).

CAUTION: If the vent valve freezes in the open position, terminate the fill by disconnecting the transfer line and then allow the vent valve to warm until it closes easily. If the vent valve remains open for a period of time, the liquid oxygen in the unit will desaturate to a pressure lower than required. If this occurs, refer to Section 2.5.6, Checking Saturation Pressure.

12. Close the source tank liquid valve when the frost melts from the transfer line assembly. Replace the fill connector cover, if present, on the Reservoir unit.

WARNING

Extreme cold hazard. Liquid oxygen discharge from the transfer line relief valve can occur. Closing the source tank liquid valve before the frost on the transfer line melts may trap liquid oxygen in the transfer line. This may cause the relief valve to open forcefully. Never place hands, arms, or face directly over the relief valve.



2.5.5 Post-Fill Inspection

Perform the following procedure to inspect the Reservoir and determine its operational status after filling it with liquid oxygen. Correct observed problems before placing the unit in service. Refer to Sections 4 and 6 as needed to correct problems.

1. Verify that the Reservoir fill connector poppet is closed and not leaking.

2. Verify that the vent valve is completely closed and not leaking.

3. Verify that the Reservoir pressure is at least 22 psig (152 kPa) within five minutes after terminating the fill.

4. Verify that there is no frost or heavy condensation on the container below the shroud.

5. Verify that all green LEDs light when the contents indicator button is depressed.

6. UNIVERSAL RESERVOIR Disconnect the pressure gauge from the Reservoir oxygen outlet DISS connector.

2.5.6 Checking Saturation Pressure

Perform the following procedure to determine the **saturation** pressure of the liquid oxygen in a Reservoir unit. A Reservoir pressure reading may not always be a true indication of the liquid oxygen saturation pressure.

1. STANDARD RESERVOIR Note the pressure indicated on the Reservoir **internal** pressure gauge.
   UNIVERSAL RESERVOIR Attach an external pressure gauge (P/N B-701732-00 or equivalent) to the Reservoir oxygen outlet DISS connector. Note the pressure indicated on the pressure gauge.

2. Momentarily open the vent valve on the Reservoir and observe the pressure gauge pointer as it drops.

3. Note the pressure value where the gauge pointer hovers (Figure 2-8) and then close the vent valve. This is the approximate saturation pressure of the Reservoir. Saturation pressure readings between 24 and 48 psig (166 and 331 kPa) for the Standard Reservoir and between 20 and 28 psig (138 and 193 kPa) for the Universal Reservoir are in the acceptable pressure range of the unit.

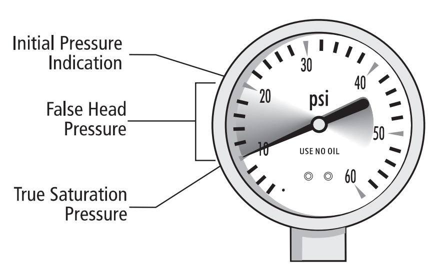


Figure 2-8: Indicator Needle "Hovering"

2.5.7 Resaturating Liquid Oxygen

If the HELiOS Reservoir looses its saturation pressure and you correct the cause of this condition without emptying the liquid oxygen contents, saturation pressure can be restored by simply allowing the unit to stand in normal room conditions. The entire volume of liquid will usually regain proper saturation within several days. If, however, this is not a reasonable option, perform the following procedure:

1. Attach the source adapter of the transfer line assembly to either the gas withdrawal valve or vent valve of the source tank. For a Universal Reservoir, attach an external pressure gauge (P/N B-701732-00 or equivalent) to the Reservoir oxygen outlet DISS connector.

2. Connect the transfer line fill adapter to the Reservoir unit fill connector and depress to engage the fill connectors.

3. Slowly open the vent valve or gas withdraw valve on the source tank and monitor the Reservoir pressure gauge. Open the source tank valve just enough to see a slow, steady rise in the pressure gauge pointer. Be sure to leave the Reservoir vent valve closed.

4. Observe the reservoir pressure gauge (Standard Reservoir) or external pressure gauge (Universal Reservoir). When the pressure gauge pointer reaches 24 psig (166 kPa), close the source tank valve.

5. Recheck the saturation pressure as described in Section 2.5.6. Repeat the resaturation procedure, if necessary, until the liquid oxygen is saturated. Be sure to reconnect the transfer line to the source tank liquid valve after completing this procedure.

2.6 OPERATING PROCEDURES

The patient typically uses the HELiOS Reservoir in two different ways. First, the Reservoir provides the patient with a liquid oxygen filling source for a portable unit. The Standard Reservoir will fill only HELiOS portable units. The Universal Reservoir will fill HELiOS portable units as well as Companion portable units. Second, the Reservoir provides gaseous oxygen for the patient to breathe when at home. The Reservoir can supply gaseous oxygen either to the H-300 Portable or to an optional external 22 PSIG (152 kPa) flow control valve. Procedures for filling a portable from the Reservoir are found in the Portable Filling Instructions sections of this manual. To operate the Reservoir as a source of gaseous oxygen to supply the H-300 Portable, perform the following steps:

1. Verify that there is adequate liquid oxygen in the Reservoir to meet patient breathing needs.

2. Insert the flexible oxygen supply tube connector into the quick connect on the front of the H-300 and snap it in place (Figure 2-9(a)).

3. Locate the oxygen DISS nut and tailpiece assembly attached to the opposite end of the flexible oxygen supply tube. Thread the nut and tailpiece assembly onto the Reservoir oxygen outlet connector until secure (Figure 2-9(b)).

4. Verify that the tube connections are leak tight.

5. Place one of the tubes from the dual-lumen oxygen cannula on the H-300 Portable oxygen outlet connector (upper connector). Place the other cannula tube on the sensor connector (lower connector). Adjust the cannula on the face to receive oxygen comfortably.

6. Set the H-300 Portable flow control knob to the prescribed oxygen flow setting.

NOTE: For additional information, refer to Section 8, H-300 Portable General Information.

(a) (b)

Figure 2-9: Flexible Oxygen Supply Tube Connections

2.7 MAINTENANCE

The Pre-Fill Inspection and Post-Fill Inspection conducted as part of the Reservoir filling procedure provide routine assessment of the functional status of the Reservoir. Functional problems observed during these inspections must be corrected before placing the unit in service.

Use the information in Table 2-2 as a guide to clean, inspect, and test the Reservoir when functional problems are observed or as needed.

NOTE: The following cleaning and disinfecting solutions are acceptable for use with the HELiOS Reservoir:

Cleaning	• Sporicidin Disinfectant Solution • Mild dish washing detergent/warm water solution
Disinfecting	• Sporicidin Disinfectant Solution • Household Bleach (1:10 dilution with water, freshly made within 24 hours)

TABLE 2-2

RESERVOIR MAINTENANCE GUIDE	
ITEM	**ACTION**
Cleaning	• Remove the upper shroud and clean the interior and exterior with a mild detergent and water. Wipe dry with a towel. Use cotton swabs in tight places. Use Scotch-Brite pad *lightly* with detergent to remove scuff marks. • Clean the contents indicator with a towel moistened with detergent and water. Wipe dry. • Clean the Reservoir plumbing and lower shroud with detergent and water. Dry with a towel and oil-free compressed gas. **NOTE:** Make sure that the fill connector and vent valve shaft are thoroughly dry before proceeding. • Remove the moisture container and thoroughly clean and dry it. Verify that the condensate drain hole in the lower shroud is open. • Clean the stainless steel container with oil-free cleaner and Scotch-Brite abrasive pad to remove scuff marks.
Inspection	• Inspect the upper and lower shrouds for cracks, warpage, and discoloration. • Verify that the warning labels (Figure 2-5) are present and legible on the upper shroud. • Verify that the Portable release mechanism moves freely and is not worn. Verify that the release button is secure on the lever and is not cracked. • Verify that the fill connector is not worn or damaged and that the poppet is not broken. • Verify that the vent valve shaft pin and valve stops are not bent or broken. • Verify that the yellow “low contents” LED lights when the contents indicator button is depressed (empty unit). Replace the 9-volt battery if the low battery LED lights. • Verify that the aluminum tubing is not bent or kinked and that a uniform air gap exists between each coil.
Testing	• Perform Leak Test (Section 4.2). • Perform Gaseous Oxygen Functional Tests (Section 4.3). • Perform Liquid Oxygen Functional Tests (Section 4.4).

Section 3

RESERVOIR THEORY OF OPERATION

This section describes the theory of operation for the HELiOS Reservoir liquid oxygen system. Two HELiOS Reservoir models are available, the Standard Reservoir and the Universal Reservoir. Each model comes in two sizes, 36 liquid liters and 46 liquid liters. The H-36 and U-36 models hold 36 liters (85 lbs/38.6 kg) of liquid oxygen while the H-46 and U-46 models hold 46 liters (110 lbs/49.9 kg) of liquid oxygen. Information presented in this section will help you understand how the HELiOS Reservoir system works. Items covered include functional descriptions of HELiOS Reservoir components and complete HELiOS Reservoir system operation.

NOTE: Numerical values used in this section are nominal values.

3.1 RESERVOIR COMPONENTS

Following is a brief description of each of the major functional components of the HELiOS Reservoir unit.

3.1.1 Cryogenic Container Liquid oxygen stored in the HELiOS Reservoir is typically saturated and boiling at a temperature somewhere between about -277°F (-186°C) and -268°F (-167°C). The constant transfer of heat from the atmosphere into the system keeps the liquid oxygen boiling and vaporizing into gas. If the heat flow into the liquid oxygen is not controlled, vaporization occurs too rapidly, and excess oxygen is vented to the atmosphere and wasted. The cryogenic container (Figure 3-1) is designed to minimize the transfer of heat from the atmosphere to the liquid oxygen contents. This is done by slowing the three methods of heat transfer: conduction, convection, and radiation.

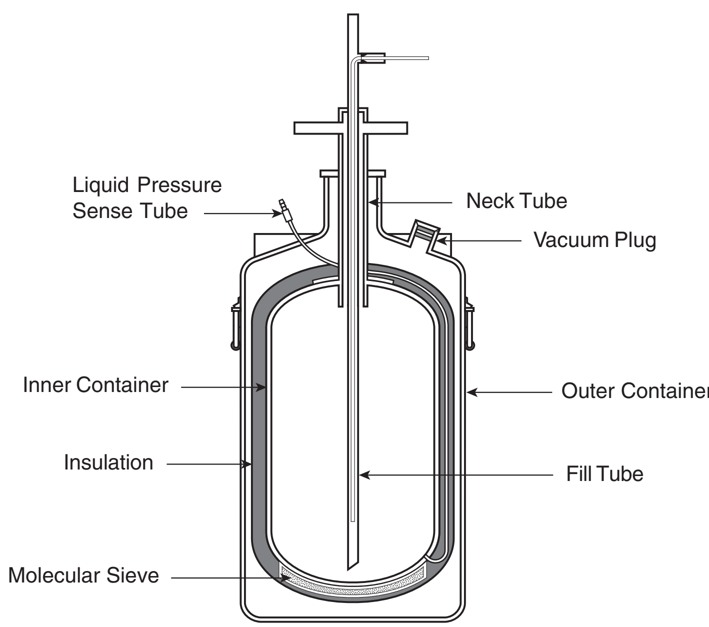


Figure 3-1: Cryogenic Container

Conduction is the transfer of heat through a material, such as metal, by collisions of molecules in the material. Molecules at the hotter end of the material are moving faster than molecules at the cooler end. Heat is transferred from molecule to molecule as fast moving molecules run into the slower moving ones. Conductive heat transfer is kept to a minimum by placing the liquid oxygen in a stainless steel inner container suspended within a stainless steel outer container. This reduces the number of places where the warmer outer container comes into physical contact with the colder inner container that holds the liquid oxygen.

Convection is the transfer of heat by motion of a heated fluid (gas or liquid) from one place to another. When a layer of gas, for example, is heated, it tends to rise above or move away from the surrounding gas. Cooler gas moves in to take its place. This gas is heated, rises and moves away. Heat is transferred by circulation of the heated gas. To minimize convective heat transfer between the warm outer container and cold inner container, air is removed from the sealed space between the outer and inner containers. A vacuum applied through the evacuation port removes most of the gas molecules in this space. Since no vacuum created on earth is perfect, a molecular sieve material is placed in the vacuum space against the inner container. When liquid oxygen in the inner container cools the molecular sieve to cryogenic temperatures, remaining gas molecules are removed from the vacuum space by adsorption into the sieve. This substantially improves the vacuum and reduces heat transfer by convection.

Radiation is the transfer of energy at the speed of light in the electromagnetic spectrum. Warm bodies emit infrared radiation, a form of light. Like visible light, mirrors and shiny surfaces reflect infrared. When infrared is absorbed, it creates a rise in temperature of the absorbing material. To minimize energy transfer by radiation, the inner container is orbital wrapped with multiple, alternating layers of aluminum foil and fiberglass paper. This insulation wrap reflects back radiant energy from the outer container and reduces radiant energy absorption by the liquid oxygen.

3.1.2 Fill Connector/Quick Connect

The fill connector/quick connect (Figure 3-2) on the HELiOS Reservoir is the male half of a fluid coupling system. It mates with the female fill connector on a HELiOS Portable (Standard Reservoir) or HELiOS and Companion portables (Universal Reservoir). The Reservoir fill connector allows liquid oxygen to transfer from the Reservoir unit into the Portable. It also allows transfer of liquid oxygen from a fill source through a transfer line into the Reservoir. Within the male fill connector is a cartridge assembly made up of a spring and a poppet. When the fill connector is disengaged, the spring holds the poppet closed and maintains a leak-tight seal. When the female fill connector engages the male fill connector, both connector poppets move back off of their respective seats (Figure 3-3). This creates an open path for liquid oxygen to transfer through the connection. A lip seal in the female fill connector assembly prevents leakage between the female and male fill connectors during liquid oxygen transfer.

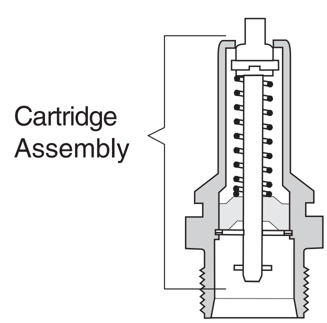


Figure 3-2: [illegible] Connector

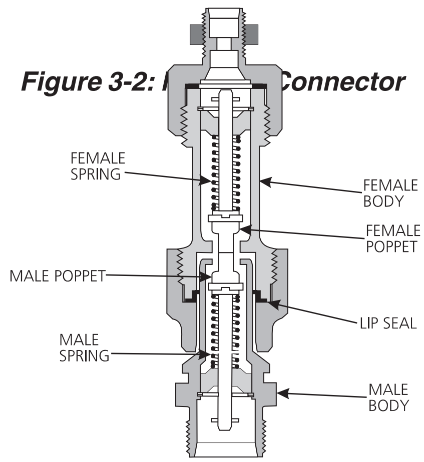


Figure 3-3: Male/Female Fill Connectors Fully Engaged

3.1.3 Vent Valve

The vent valve (Figure 3-4) is a quarter turn ball valve that vents the HELiOS Reservoir inner container to atmosphere. Venting of the inner container is required to fill the Reservoir with liquid oxygen. A vent valve wrench engages the valve shaft to activate the valve. When the valve is closed, the hole through the valve ball is at 90° to the inlet and outlet ports of the valve. Flow through the valve is stopped. When the valve shaft is rotated 90° with the vent wrench, the hole in the valve ball lines up with the inlet and outlet ports. Flow through the valve occurs. The fill technician can partially close the vent valve to restrict maximum vent flow and help maintain adequate pressure in the Reservoir during filling.

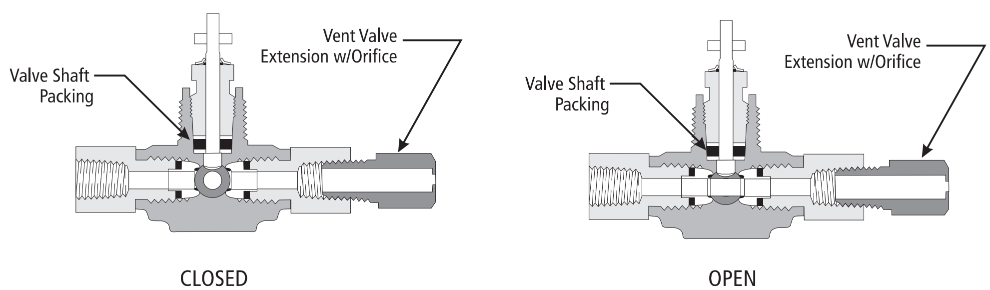


Figure 3-4: Vent Valve

3.1.4 Relief/Economizer Valve

The relief/economizer valve is a pressure-regulating device that combines the function of a primary relief valve and an economizer valve into one component (Figure 3-5).

The primary relief valve establishes the system pressure of the HELiOS Reservoir unit when there *is no* oxygen flow through the oxygen outlet ("Standby" condition). It contains a spring-loaded diaphragm that, in its normal state, seals a port that is vented to atmosphere. System pressure acts on one side of the diaphragm. When this pressure overcomes the force created by the spring and atmospheric pressure acting on the opposite side, the diaphragm lifts off of the port. This allows gas in the space above the liquid oxygen (headspace) to vent to atmosphere. The venting gas lowers the system

pressure until equilibrium is established between the opening and closing forces on the diaphragm. The rate at which gas is vented out the primary relief valve is determined by the normal evaporation rate (NER) of the system. The Standard Reservoir maintains a primary relief valve nominal pressure of 45 psig (311 kPa) when in the Standby condition. The Universal Reservoir maintains a primary relief valve nominal pressure of 26 psig (179 kPa) when in the Standby condition.

The economizer valve establishes the system pressure of the Reservoir unit when there *is* oxygen flow through the oxygen outlet ("Oxygen Flow" condition). It allows a patient to first breathe gaseous oxygen from the headspace in the Reservoir. This headspace gas accumulates and builds pressure due to the constant boiling of the liquid oxygen at the normal evaporation rate (NER). Oxygen is conserved by allowing the patient to withdraw and use this gas rather than letting it build pressure and eventually vent away through the primary relief valve. The economizer valve contains a spring-loaded diaphragm that, in its normal state, seals a port that is connected to the Reservoir oxygen outlet circuit. When system pressure exceeds 27 psig /186 kPa (Standard Reservoir) or 22 psig /152 kPa (Universal Reservoir) the economizer diaphragm lifts off of its port. This opens a flow path between the gaseous headspace and the oxygen outlet. When flow through the oxygen outlet is established, gas moves from the headspace through the open economizer valve. When this flow is greater than the NER of the system (about 1/4 L/min.), headspace pressure begins to decrease. The pressure will eventually decrease to a point where the opening force on the diaphragm created by the pressure and the closing force created by the spring come to equilibrium. This equilibrium is maintained at 27 psig /186 kPa (Standard Reservoir) or 22 psig/152 kPa (Universal Reservoir) because the economizer valve stays open just enough to allow the small NER flow to pass through. If the outlet flow demand exceeds the NER flow (about 1/4 L/min.) when at economizer pressure, liquid oxygen is withdrawn and vaporized in the warming coil. This flow, together with the small NER flow through the economizer valve, satisfies the flow demand on the system. When the flow demand at the oxygen outlet stops, the NER causes pressure to build toward the primary relief valve set point.

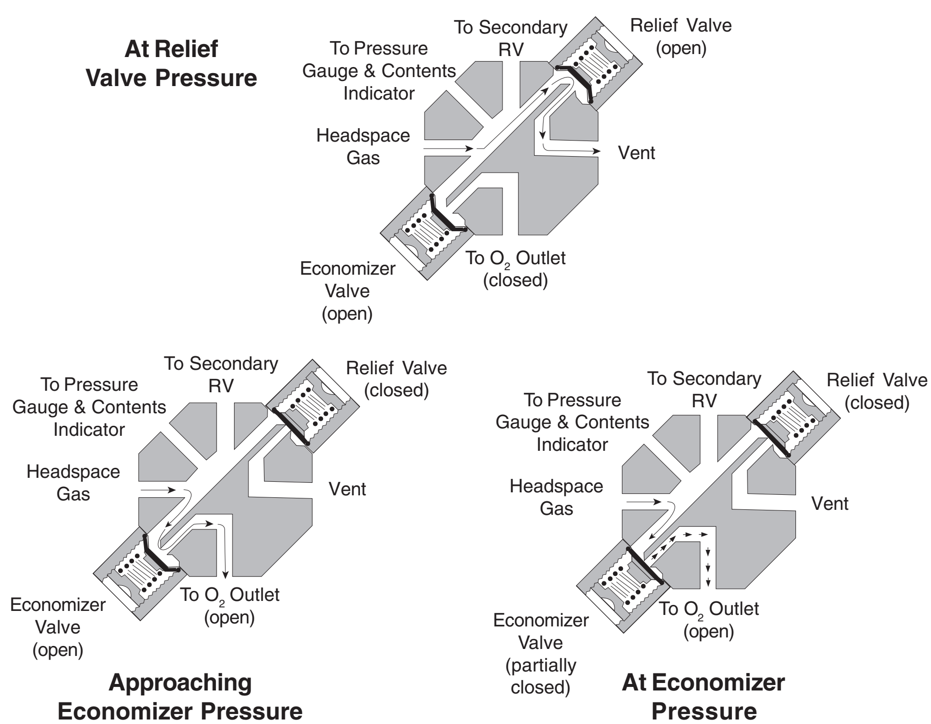


Figure 3-5: Relief/Economizer Valve

3.1.5 Secondary Relief Valve

The secondary relief valve in the HELiOS Reservoir is used as a safety backup in the event that the primary relief valve fails to limit system pressure to an acceptable range. It is mounted on the relief/economizer valve body. The secondary relief valve consists of a poppet with an elastomer seal and a spring (Figure 3-6). In its normal state, the poppet seals a port that vents to atmosphere. When system pressure acting on one side of the poppet overcomes the force created by the spring and atmospheric pressure, the poppet lifts off its seat and allows headspace gas to vent to atmosphere. The venting gas lowers the system pressure until equilibrium is established between the opening and closing forces on the poppet. If system pressure increases further, the relief valve poppet opens a greater amount and vents additional gas to maintain the force equilibrium on the poppet. The secondary relief valve has a nominal pressure setting of 70 psig /483 kPa (Standard Reservoir) or 30 psig / 207 kPa (Universal Reservoir).

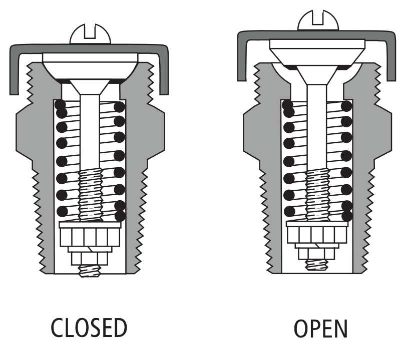


Figure 3-6: Secondary Relief Valve

3.1.6 Pressure Regulator (Standard Reservoir Only)

The adjustable pressure regulator reduces the pressure of the oxygen gas leaving the HELiOS Standard Reservoir oxygen outlet to a constant 22 psig (152 kPa). The regulator ensures that the Reservoir outlet pressure stays constant despite changes in the inlet pressure and changes in downstream flow requirements. System pressure at the regulator inlet varies between 27 psig (186 kPa) and 45 psig (311 kPa) depending on how long the Reservoir is in the oxygen delivery mode or in the standby mode.

The pressure regulator (Figure 3-7) consists of an adjusting knob, regulator spring, diaphragm/pin assembly, spring-loaded poppet valve, and separate open flow restrictor connector. Adjustment of the knob compresses the regulator spring to apply a downward force on the diaphragm/pin assembly. This forces the spring-loaded poppet open and allows gas from the warming coil to flow through the regulator to the downstream oxygen outlet. An increase in the downstream outlet pressure applies an upward force to the bottom of the diaphragm/pin assembly. The diaphragm/pin assembly moves upward until the force acting on it from below balances the spring force from above. When there is no downstream flow demand, this balance of forces allows the spring-loaded poppet valve to close at 22 psig (152 kPa). When there is downstream flow demand, the initial imbalance of forces across the diaphragm/pin assembly opens the spring-loaded poppet valve just enough to compensate for the flow demand. This re-establishes equilibrium at 22 psig (152 kPa).

The open flow restrictor connector is installed in the pressure regulator inlet port. It limits maximum flow through the regulator to about 30 L/min. This safety device prevents an abnormally high flow demand from overcoming the heat exchange capacity of the warming coil and causing a discharge of liquid oxygen.

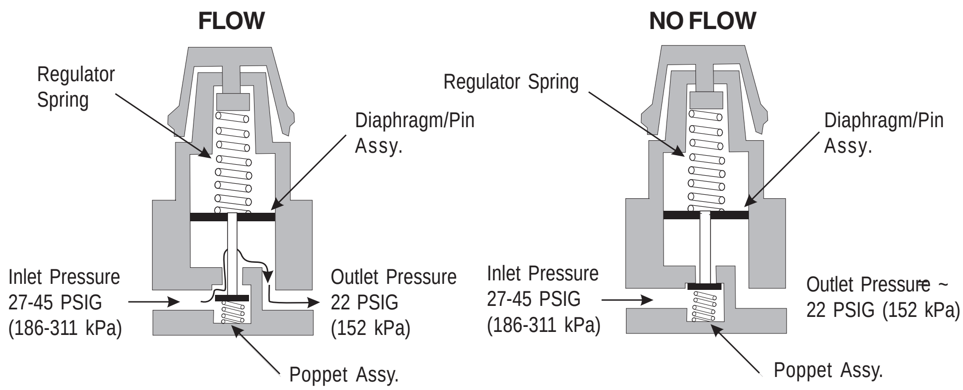


Figure 3-7: Pressure Regulator

3.1.7 Warming Coil

The warming coil on the HELiOS Reservoir is a loosely wound coil of ¼ in. aluminum tubing over 20 feet (6 meters) long that connects the liquid withdrawal tube and the economizer valve outlet to the pressure regulator (Figure 3-8). The warming coil is a heat exchanger that transfers heat from the surrounding atmosphere to the fluid contents inside the coil. Oxygen flows through the warming coil only when there is a flow demand at the oxygen outlet. The warming coil performs two functions on the Reservoir. First, it warms the cold gaseous oxygen from the headspace that flows through the economizer valve. The patient breathes this gas while the Reservoir pressure is greater than the economizer setting. Second, it vaporizes liquid oxygen that is discharged from the Reservoir liquid withdrawal tube. This occurs when there is ongoing patient flow demand once system pressure stabilizes at the economizer setting.

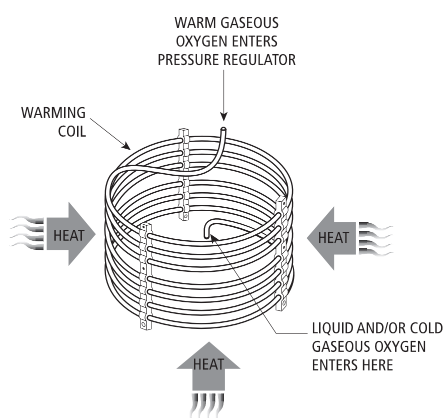


Figure 3-8: Warming Coil

3.1.8 Oxygen Outlet w/Poppet Valve

The HELiOS Reservoir oxygen outlet is a DISS, 9/16-18 threaded connector with an integral poppet valve (Figure 3-9). A mating nut and nipple, when threaded onto the oxygen outlet, move the poppet valve poppet off of its seat to allow flow through the connection. When the nut and nipple are disconnected, the poppet valve spring reseats the poppet to stop flow. The nut and nipple are typically part of an oxygen supply tube assembly or a flow control device.

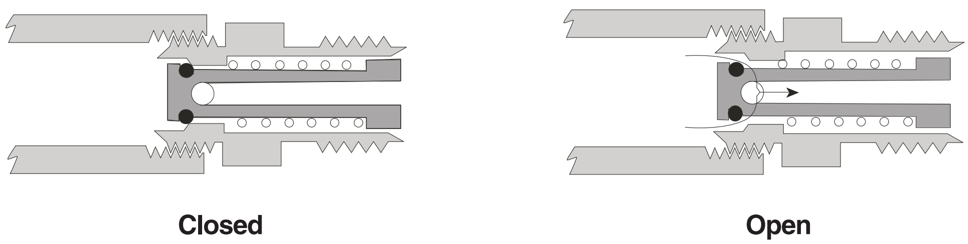


Figure 3-9: Oxygen Outlet w/Poppet Valve

3.1.9 Pressure Indicator (Standard Reservoir Only)

The HELiOS Standard Reservoir pressure indicator (Figure 3-10) is a bourdon tube pressure gauge that indicates the status of the system headspace pressure. The indicator dial is calibrated from 0 to 100 psig (0 to 7 bar). The pressure indicator is used to evaluate the Standard Reservoir system headspace pressure during a fill and during system operation. The pressure indicator does not indicate Standard Reservoir oxygen outlet pressure. The Standard Reservoir pressure regulator reduces the oxygen outlet pressure to a value lower than the headspace pressure.

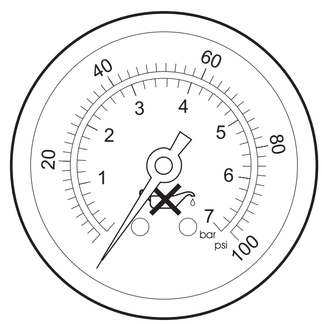


Figure 3-10: Pressure Indicator

3.1.10 Contents Indicator

The contents indicator, visible through the upper shroud of the Reservoir, measures and displays the amount of liquid oxygen remaining in the HELiOS Reservoir (Figure 3-11). It is powered by a nine-volt alkaline battery. The system is based on the principle that the pressure created at the bottom of a tank of liquid is proportional to the height of the liquid. An electronic pressure transducer measures the pressure at the bottom of the inner container created by the level of liquid oxygen. However, this pressure signal is also a function of gaseous headspace pressure acting on top of the liquid. So the transducer measures the gaseous headspace pressure and subtracts the value from the total pressure at the bottom of the inner container. It sends the resulting electronic signal that is proportional to the level of liquid oxygen to the circuit board in the indicator. Eight green LEDs on the indicator display panel represent the full to empty range of the system. When the patient depresses a push button, a proportional number of green LEDs light to represent

the relative level of liquid oxygen remaining in the Reservoir. In addition to the green LEDs, a yellow “low contents” LED on the contents indicator lights when 8.5 pounds (3.9 kg) of liquid oxygen remain. A yellow “low battery” LED lights when the battery voltage drops below a predetermined value. Each contents indicator contains an electronic connector to interface with the Teleview remote contents monitoring system.

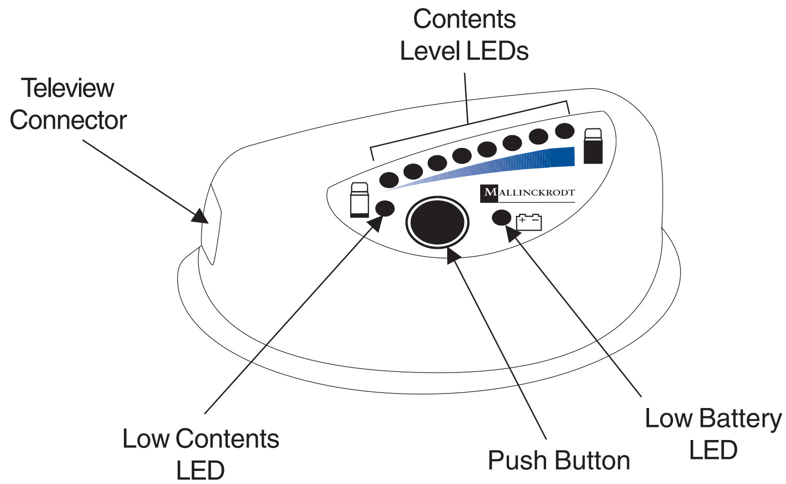


Figure 3-11: Contents Indicator

3.2 RESERVOIR OPERATION

The HELiOS Reservoir provides a source of liquid oxygen to fill portable units. It also provides gaseous oxygen to an H-300 Portable, OxiClip™ conserver, or 22 psig flow control valve connected to the oxygen outlet connector. The following information provides a brief description of Reservoir system operation while filling the unit, at fill termination, during no use standby, during gaseous oxygen withdrawal, and over a 24-hour period.

3.2.1 Filling the Reservoir

A technician typically fills the Reservoir from a liquid oxygen source saturated at 40 to 50 psig (276 to 345 kPa). The fill sequence begins by engaging the liquid oxygen transfer line assembly to the Reservoir fill connector. The technician then opens the Reservoir vent valve to permit gas within the Reservoir to escape to atmosphere (Figure 3-12). This creates the pressure drop necessary for the liquid oxygen to flow from the source vessel into the Reservoir. At first, the liquid oxygen that leaves the source vessel vaporizes into gas in the transfer line and vents to atmosphere through the Reservoir vent valve. This “flash off” is due to the relatively warm temperature of the transfer line and Reservoir container. Also the pressure drop created by the open vent valve lowers the pressure on the saturated liquid oxygen in the source vessel. This creates a supersaturated condition where the liquid oxygen boils and vaporizes rapidly to reduce its saturation temperature to match the new lower pressure. The vaporization process cools the transfer line and Reservoir inner container within a short time to a temperature that enables liquid oxygen to remain in the container. The technician can adjust the vent valve opening to control the rate of vent gas flow and to maintain a desired liquid oxygen saturation pressure of 24 psig (166 kPa) in the Reservoir.

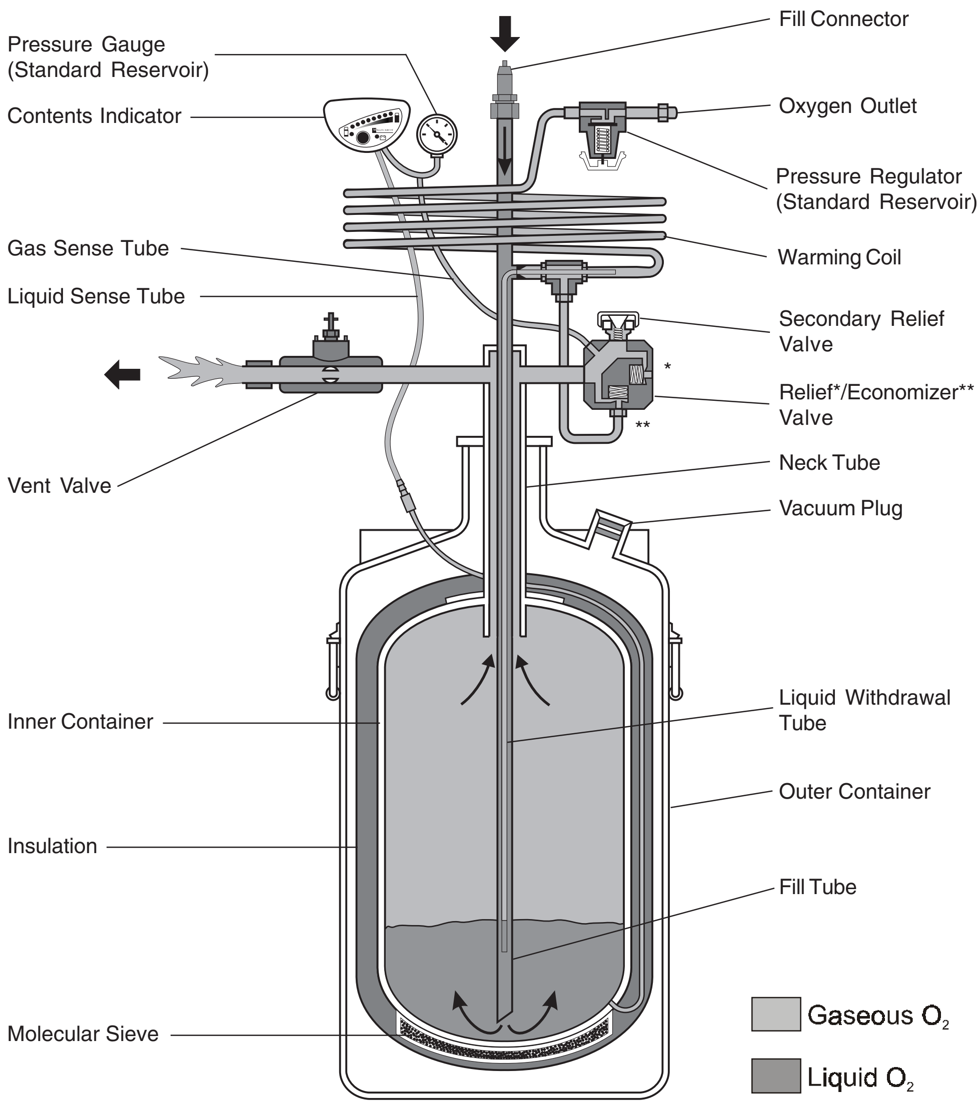


Figure 3-12: Filling the Reservoir

3.2.2 Fill Termination

When the liquid oxygen level in the Reservoir inner container reaches the end of the neck tube, liquid oxygen travels up the neck tube and discharges through the open vent valve (Figure 3-13). The venting sound changes and the liquid oxygen creates a dense vapor cloud as it discharges from the vent valve. When this occurs, the technician terminates the filling operation by closing the vent valve and disengaging the transfer line from the Reservoir.

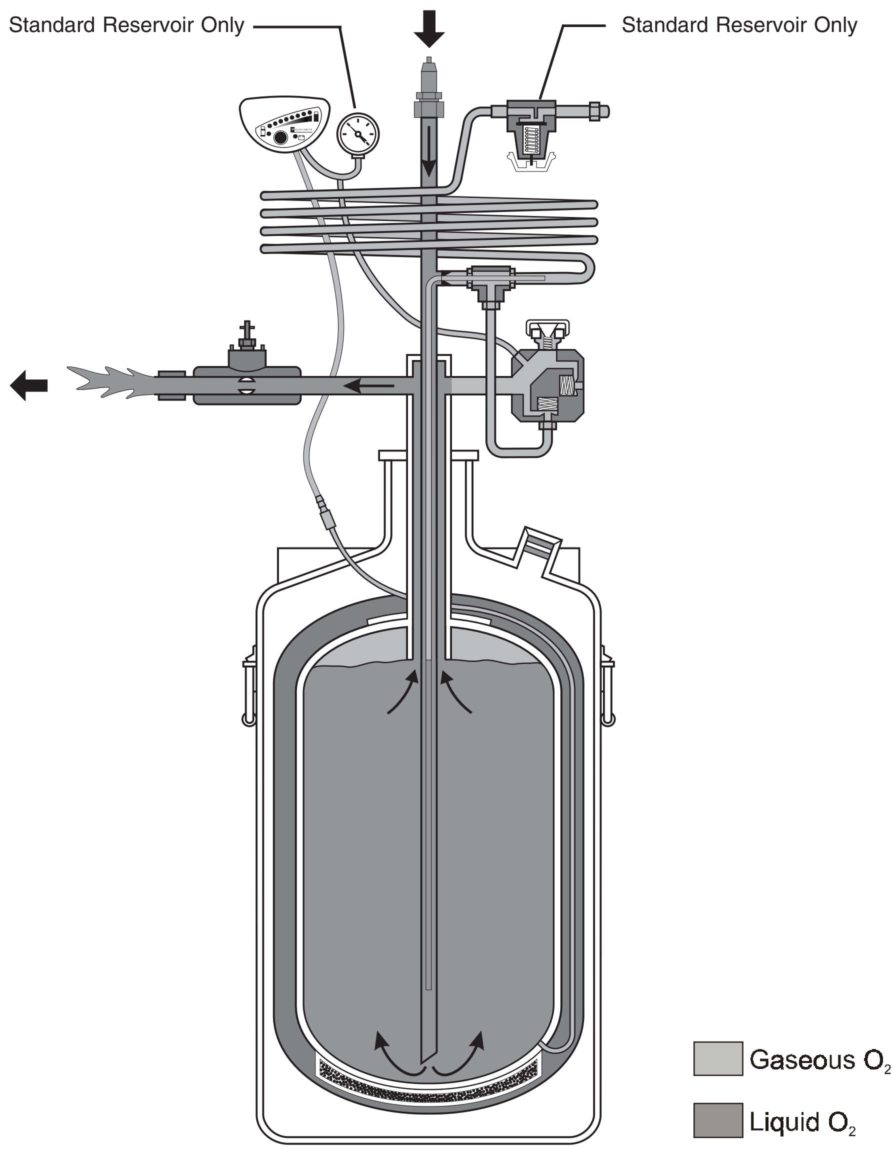


Figure 3-13: Fill Termination

3.2.3 Standby

When the Reservoir contains liquid oxygen, and there is no oxygen flow demand on the system, the pressure in the system increases and eventually stabilizes at the primary relief valve set point, approximately 45 psig / 311 kPa for the Standard Reservoir or 26 psig / 179 kPa for the Universal Reservoir (Figure 3-14). The pressure increases due to the Normal Evaporation Rate (NER) of the system. The NER is a function of the constant rate at which ambient heat "leaks" into the liquid oxygen and causes it to boil when saturated. This constant boiling vaporizes some of the liquid oxygen into gas. Pressure increases in the container over time until it reaches the primary relief valve opening point. The primary relief valve maintains pressure equilibrium in the system by allowing gas in the container space above the liquid (headspace) to vent at the same rate that it is created by the NER. The vented gas represents the system's NER loss. Due to the efficient design of the container, NER losses are kept to a minimum.

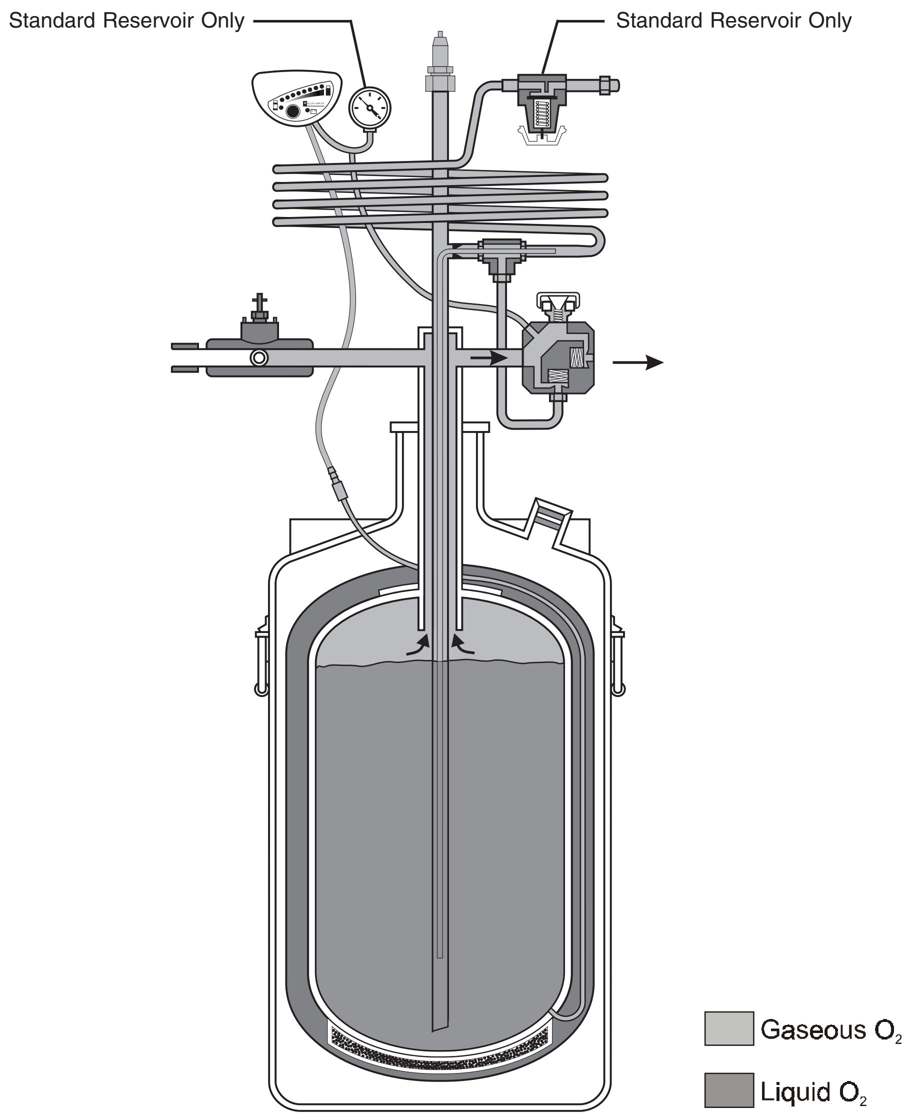


Figure 3-14: Standby

3.2.4 Gaseous Oxygen Use

Oxygen that flows through the Reservoir oxygen outlet can come from two locations within the Reservoir: the headspace above the liquid oxygen and the liquid withdrawal tube. When the pressure inside the Reservoir unit is greater than the economizer set point, the economizer valve opens. A flow demand at the oxygen outlet moves gas out of the pressure regulator and warming coil and creates a pressure drop at the outlets of the economizer valve and liquid withdrawal tube. As a result, headspace pressure drives gaseous oxygen from the headspace, through the open economizer valve, warming coil, and pressure regulator to meet the demand at the oxygen outlet (Figure 3-15). Liquid oxygen does not move up through the liquid withdrawal tube because the gas pressure above the liquid in the tube remains the same as the headspace pressure above the liquid in the container. When the oxygen outlet flow demand is greater than the NER of the system, gas leaves the headspace faster than it is created by the NER. The pressure in the headspace begins to decrease. If the flow demand continues, the pressure in the headspace will eventually reach the set point of the economizer valve, 27 psig / 186 kPa (Standard Reservoir) or 22 psig / 152 kPa (Universal Reservoir).

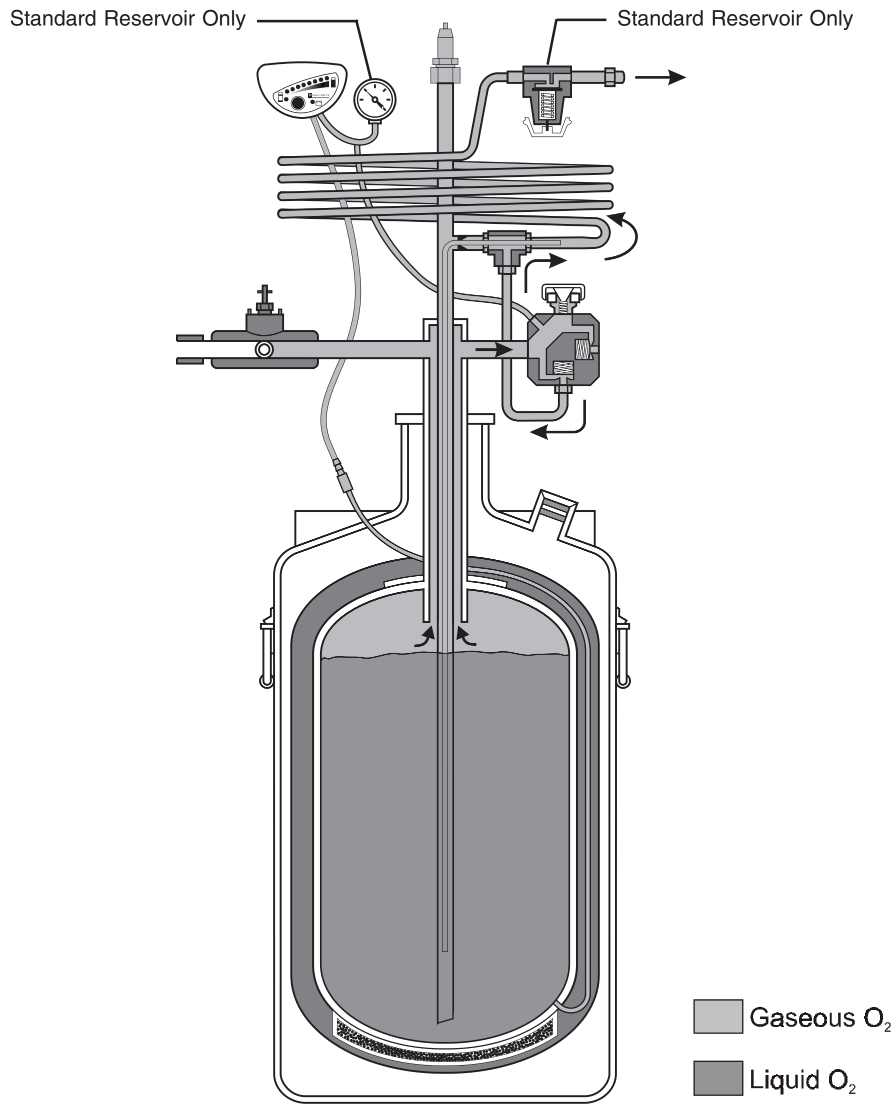


Figure 3-15: Oxygen Flow Through Economizer Circuit

When headspace pressure reaches the economizer set point, the economizer valve spring force overcomes the opposing force created by the pressure acting on the valve diaphragm and closes down the valve. However, the economizer valve stays open just enough to allow the small flow of headspace gas created by the NER to pass through. Since this creates equilibrium, where there is no net increase or decrease of gas in the headspace, system pressure remains constant. If the flow demand at the oxygen outlet is greater than the NER flow passing through the economizer valve, pressure at the outlet of the liquid withdrawal tube now drops below the headspace pressure over the liquid oxygen in the container. The higher headspace pressure moves liquid oxygen up the liquid withdrawal tube and into the warming coil (Figure 3-16). The liquid oxygen vaporizes in the warming coil and the resulting oxygen flow combines with the small NER flow coming from the economizer valve. The combined total flow passes through the warming coil to the oxygen outlet at the desired rate. The Reservoir remains at economizer pressure until the flow demand at the oxygen outlet stops. In the Standard Reservoir, the pressure regulator maintains a constant outlet pressure of 22 psig (152 kPa) as oxygen flow demands vary and system internal pressure swings between 45 psig and 27 psig (311 kPa and 186 kPa). In the Universal Reservoir, a pressure regulator is not required since the system internal pressure swing is much smaller, between 26 psig and 22 psig (179 kPa and 152 kPa). The economizer valve maintains a constant outlet pressure of 22 psig (152 kPa) while gas flows to the patient.

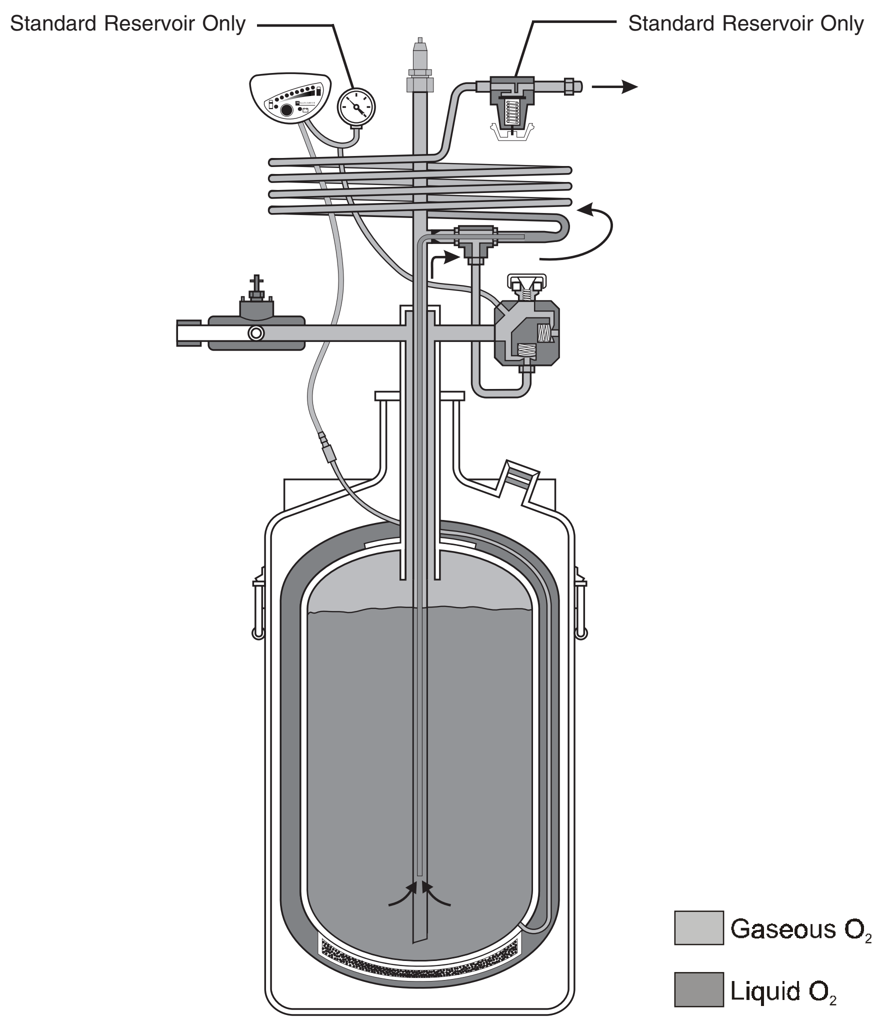
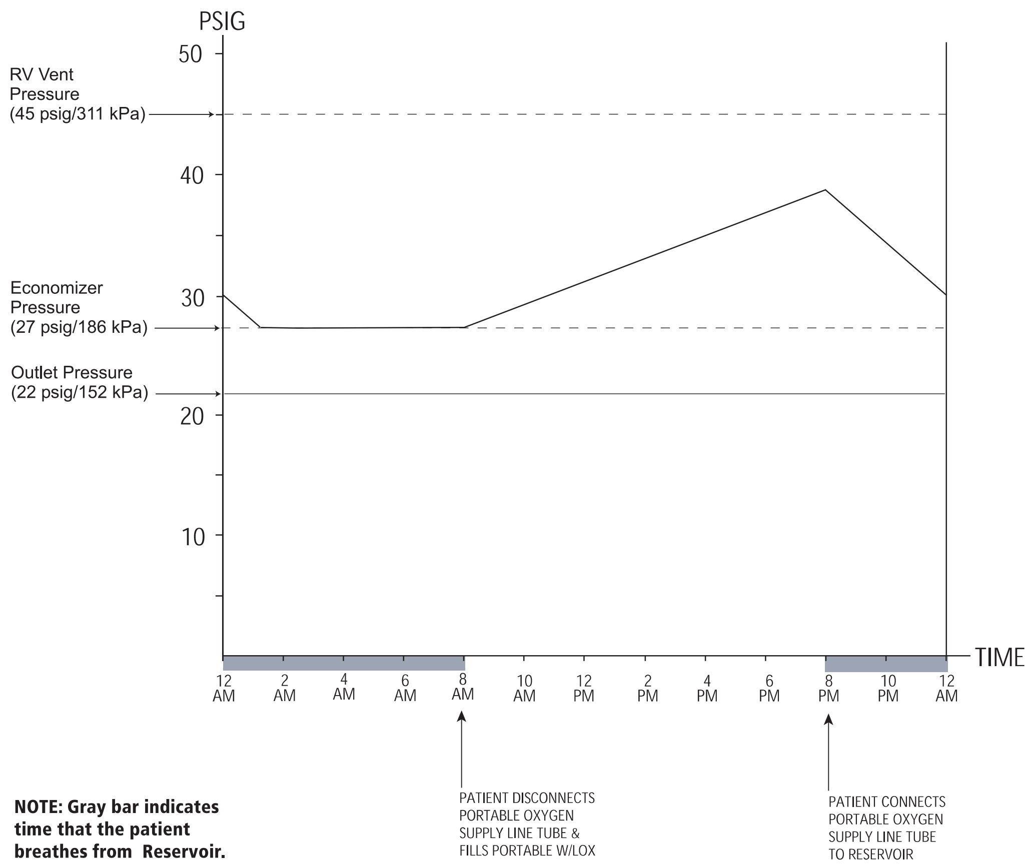


Figure 3-16: Oxygen Flow Through Liquid Withdrawal Circuit

3.2.5 HELiOS Reservoir Operation Over 24 Hours

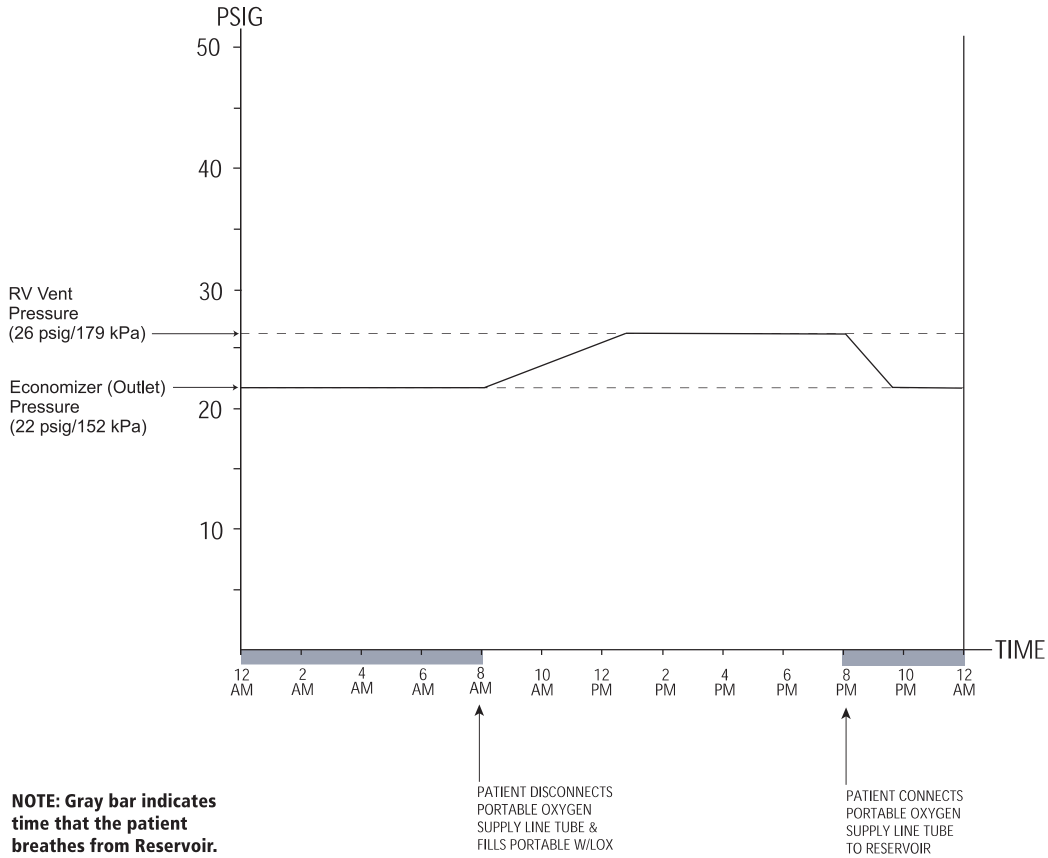
When using the HELiOS system, a patient is typically always connected to the H-300 Portable. If patient ambulation is required, the patient fills the H-300 with liquid oxygen from the Reservoir. A full H-300 provides oxygen to the patient for about 10 hours at a flow control setting of 2. When at home, during sleep or other sedentary activities, the patient may connect the H-300 to the Reservoir by means of a flexible oxygen supply tube. While breathing gaseous oxygen from the Reservoir through the H-300, the gas pressure in the Reservoir will typically remain lower than the primary relief valve venting pressure. This concept provides ambulation and flexibility for the patient while eliminating or greatly reducing evaporative losses.

Figure 3-17 shows the change in pressure in the Standard Reservoir as a patient uses the system over a typical 24-hour period. When the patient breathes gaseous oxygen from the Reservoir through the connected H-300, Reservoir headspace pressure drops. This allows the relief valve to close and stop evaporative (NER) losses. The pressure drop continues until a steady state is reached at economizer pressure. When the patient disconnects the H-300 and fills it with liquid oxygen from the Reservoir for ambulatory use, gaseous oxygen flow from the Reservoir stops. The Reservoir NER causes the headspace pressure to slowly increase over time and approach the relief valve opening point. With a Standard Reservoir, it can typically take 15 hours or longer before the Reservoir vents gas through the relief valve again. If the patient reconnects the H-300 and breathes gaseous oxygen from the Reservoir before headspace pressure reaches the relief valve opening pressure, no venting occurs. Evaporative losses are essentially eliminated, resulting in greater time between Reservoir fills.



3-17: Standard Reservoir Pressure Over 24 Hours

Figure 3-18 shows the change in pressure in the Universal Reservoir as a patient uses the system over a typical 24-hour period. The operation is similar to the Standard Reservoir. However, when there is no gaseous oxygen flow from the Reservoir to the H300, the time it takes for the headspace pressure to build to the relief valve opening point is shorter. This is because the Universal Reservoir primary relief valve is set to open at a lower value (26 psig/179 kPa). As a result, it typically takes only 3-4 hours before the Universal Reservoir begins to vent gas through the relief valve. Evaporative losses are greatly reduced but typically not eliminated with this system, resulting in slightly reduced efficiencies.



3-18: Universal Reservoir Pressure Over 24 Hours

Section **4**

RESERVOIR PERFORMANCE VERIFICATION

This section provides testing information to verify Reservoir performance for any of the following reasons:

- To determine the cause of operational failure.
- To check the unit's overall system operation after the repair or replacement of a component.
- To verify that the unit operates within specifications as a function of routine maintenance.

NOTE: Remove the Reservoir upper shroud to conduct the performance verification tests.

4.1 EQUIPMENT REQUIRED

The following equipment is required to complete the performance verification tests in this section:

1) Medium flat-blade screwdriver
2) Vent valve wrench (P/N B-775182-00).
3) Source of liquid oxygen saturated at 40 to 50 psig (276 to 311 kPa).
4) Pressurizing fixture (P/N B-701731-00).
5) Adjustable 0 to 100 psig (0 to 690 kPa) gaseous oxygen source.
6) Calibrated 0 to 200 lb. (0 to 91 kg) weight scale.
7) Liquid leak detector – SNOOP (P/N B-775272-00).
8) Micro bar clamp (American Tool 6 in. Quick-Grip).
9) 0-100 psig test pressure gauge w/ tubing adapter (P/N B-701732-00).
10) Test flowmeter, 0-40 L/min (optional).
11) 0-10 L/min, 22 psig external flow control valve (P/N B-701655-00).
12) Oxygen DISS wye outlet adapter w/ two demand check valve outlets (Bay Corporation, Westlake, OH (888-835-3800) - P/N YO-124DV or Medical Fittings, Inc., Northhampton, PA (800-331-2685) - P/N 7211 or equivalent).

NOTE: It is important to use a calibration schedule for test equipment used for Reservoir performance testing. Follow recommendations in Test Equipment Calibration, Section 1.7 to ensure accurate test results.

NOTE: Do not use pressure gauges or flowmeters that have been dropped or mishandled. They must be calibrated before placing them back into service.

4.2 LEAK TESTS

Liquid oxygen leakage from the Reservoir unit in any amount is unacceptable and calls for the immediate removal from service of any such leaking unit. Minor gas leaks in connections and fittings will not affect system operation provided they do not exceed the Normal Evaporation Rate (NER) of the unit. Either of the following leak test procedures will determine the presence of external leaks. Use the Liquid Leak Detector Test to determine the *presence* and *location* of any substantial leaks. Use the Pressure Hold Test to determine if the total system leak rate is acceptable.

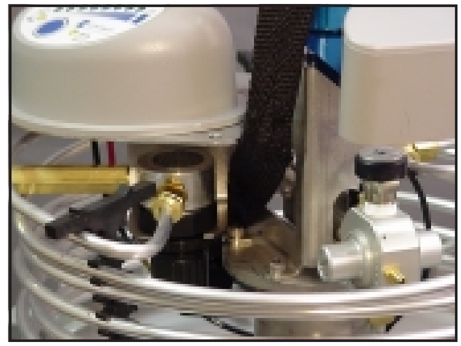
4.2.1 Liquid Leak Detector Test

The liquid leak detector test may be performed on Reservoir units that contain pressurized liquid or gaseous oxygen.

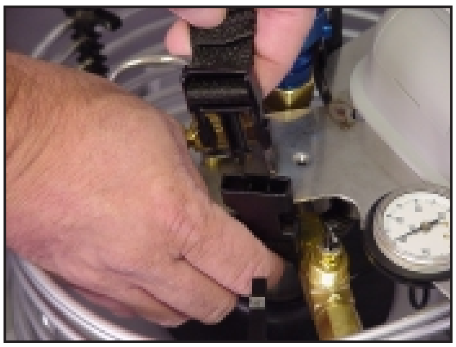
1. STANDARD RESERVOIR Attach the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir unit and secure it with the attached strap (Figure 4-1). If the Reservoir contains liquid oxygen, verify that it is pressurized between 24 and 48 psig (166 and 331 kPa). If the pressure is out of range refer to Reservoir Troubleshooting, Section 5. If the Reservoir does not contain liquid oxygen, connect an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture (Figure 4-2). Pressurize the Reservoir with gaseous oxygen to **40 psig (276 kPa)**.

   UNIVERSAL RESERVOIR Attach the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir unit and secure it with the attached strap (Figure 4-1). If the Reservoir contains liquid oxygen, verify that it is pressurized between 20.5 and 28 psig (141and 193 kPa). If the pressure is out of range refer to Reservoir Troubleshooting, Section 5. If the Reservoir does not contain liquid oxygen, connect an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture (Figure 4-2). Pressurize the Reservoir with gaseous oxygen to **22 psig (152 kPa)**.

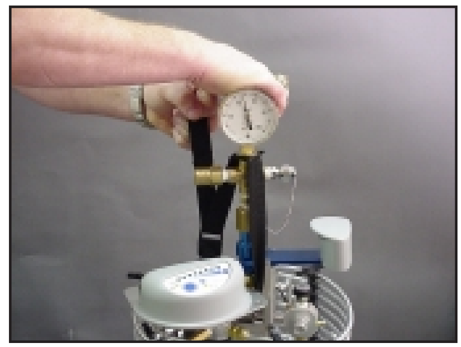
(a) Place coated strap end between contents indicator and R/E valve



(b) Route strap between pressure regulator and container flange



(c) Adjust strap to its longest length and snap together connectors



(d) Push fixture down and pull up on loose end of strap to secure

Figure 4-1: Securing Pressurizing Fixture to Reservoir

(a) Hose Connected to DISS Inlet

(b) Adjustable Pressure Source

Figure 4-2: Gaseous Oxygen Connected to Pressurizing Fixture

WARNING

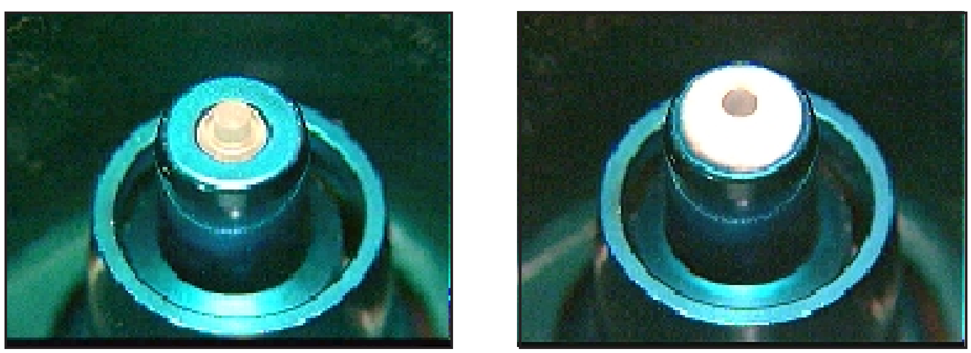
Extreme cold hazard. Rapid discharge of liquid oxygen and/or system malfunction can occur. Use only Snoop liquid leak detector on the Reservoir unit fill connector. When finished with leak test, rinse the fill connector with clean water and blow dry completely with gaseous oxygen or nitrogen.

NOTE: When using Snoop on the stem of the vent valve, be sure to blow it dry with gaseous oxygen or nitrogen.

2. Use liquid leak detector to test all Reservoir fittings and connections. Be sure to test the fill connector compression fitting (large brass nut). Place a finger wetted with Snoop lightly against the vent valve outlet to test for leakage. Place a finger wetted with Snoop lightly against the DISS oxygen outlet to test for leakage.

3. Disconnect and remove the pressurizing fixture from the Reservoir fill connector. Apply Snoop to the fill connector poppet and check for leakage.

NOTE: A small amount of leakage around the poppet of the male fill connector is acceptable. Acceptable leaks appear as white, foam-like bubbles in the liquid leak detector. If the bubbles created by the leak detector are considerably larger than those shown in Figure 4-3 after 30 seconds, make necessary repairs to the male fill connector according to Reservoir Service and Repair, Section 6.6.



(a) **(b)**

Figure 4-3: Leak Testing the Fill Connector

4. Make repairs to leaking fittings or connections per Reservoir Service and Repair, Section 6.

5. If the Reservoir continues to experience pressure related problems, perform the Pressure Hold Test to determine if an external leak is the source of the problem.

4.2.2 Pressure Hold Test (Alternate Leak Test)

NOTE: Conduct the Pressure Hold Test on Reservoirs with **empty, warm** inner containers only. Performing this test on units that contain liquid oxygen yields inaccurate results. If the Reservoir contains liquid oxygen, remove the liquid oxygen from the unit per Reservoir Service and Repair, Section 6.1. Then warm the container by connecting gaseous oxygen to the fill connector and opening the vent valve. Allow gaseous oxygen to purge the container for about 45 minutes.

1. STANDARD RESERVOIR Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture. Momentarily engage the pressurizing fixture to the Reservoir fill connector and pressurize the unit to 45 psig (311 kPa) (Figure 4-4). Remove the pressurizing fixture. Let the unit stand for 10 minutes to allow the pressure inside the Reservoir to stabilize.

   UNIVERSAL RESERVOIR Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture. Momentarily engage the pressurizing fixture to the Reservoir fill connector and pressurize the unit to 24 psig (166 kPa) (Figure 4-4). Remove the pressurizing fixture. Let the unit stand for 10 minutes to allow the pressure inside the Reservoir to stabilize.

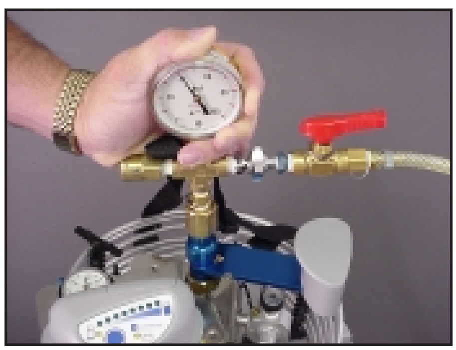


Figure 4-4: Pressurizing Reservoir

Figure 4-5: Checking Pressure

2. Disconnect the gaseous oxygen source from the pressurizing fixture and momentarily engage the pressurizing fixture to the fill connector (Figure 4-5). Record the initial time and pressure. Lightly tap the pressure gauge with your finger to assure that the needle is reading properly.
   STANDARD RESERVOIR Verify that the pressure is 43-45 psig (297-311 kPa).
   UNIVERSAL RESERVOIR Verify that the pressure is 22-24 psig (152-166 kPa).
   Remove the pressurizing fixture. Repeat step 1 if the pressure is not within tolerance.

3. After 14 to 15 hours, engage the pressurizing fixture (without the gaseous oxygen source) and take a final reading.
   STANDARD RESERVOIR Verify that the pressure is greater than 36 psig (248 kPa) for an H-46 or greater than 35 psig (241 kPa) for an H-36.
   UNIVERSAL RESERVOIR Verify that the pressure is greater than 18 psig (124 kPa) for a U-46 or greater than 17 psig (117 kPa) for a U-36.
   If the pressure is out of specification, perform the Liquid Leak Detector Test to determine the source of the leak.

4.3 GASEOUS OXYGEN FUNCTIONAL TESTS

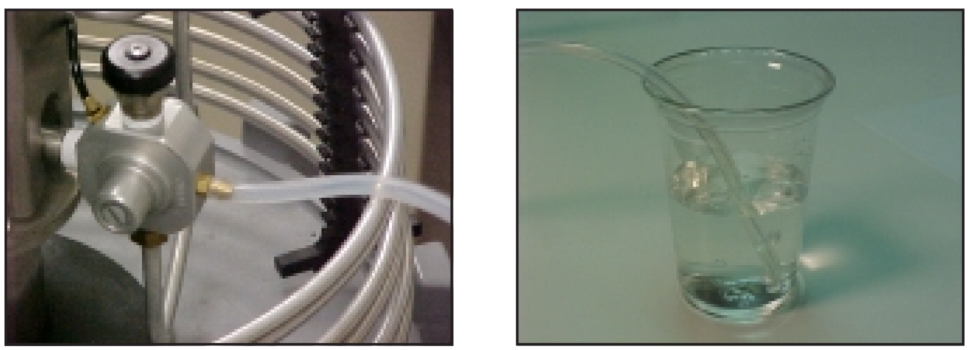
Conduct the following tests on an empty Reservoir unit that has warmed to room temperature.

4.3.1 Primary Relief Valve Test

The primary relief valve maintains system pressure at a preset value when the Reservoir contains liquid oxygen and is in the standby mode. The primary relief valve is part of the relief/economizer (R/E) valve. This test uses only gaseous oxygen to determine if the primary relief valve opens within its acceptable range

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-2).

2. The primary relief valve vents through the barbed fitting in the side of the R/E valve. Attach one end of a 1/8-in. I.D. flexible tube to the barbed fitting. Insert the other end of the tube into a clean jar of water (Figure 4-6).



(a) **(b)**

Figure 4-6: Primary RV Test Setup

3. *Slowly* pressurize the Reservoir until a continuous stream of small bubbles first appears in the jar of water.

4. STANDARD RESERVOIR Verify that the primary relief valve opens (bubbles) at 42-48 psig (290-331 kPa). If the opening pressure is not within the acceptable range, adjust the primary relief valve per Reservoir Service and Repair, Section 6.8.3. Replace the R/E valve if unable to maintain primary relief valve pressure.

   UNIVERSAL RESERVOIR Verify that the primary relief valve opens (bubbles) at 24-28 psig (166-193 kPa). If the opening pressure is not within the acceptable range, adjust the primary relief valve per Reservoir Service and Repair, Section 6.8.3. Replace the R/E valve if unable to maintain primary relief valve pressure.

4.3.2 Secondary Relief Valve Test

The secondary relief valve serves as a safety or backup to the primary relief valve. Under normal operating conditions, the secondary relief valve remains closed. The relief valve opens at a specified pressure greater than the opening pressure of the primary relief valve. This test uses only gaseous oxygen to determine if the secondary relief valve opens within its acceptable range.

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-2).

2. Obtain a 6 in. Quick-Grip micro bar clamp (Figure 4-7 (a)). Position the movable bar clamp arm over the R/E valve vent barbed fitting. Position the fixed bar clamp arm on the edge of the mounting bracket window cutout (Figure 4-7 (b)). Tighten the clamp to seal the vent port.

(a) (b)

Figure 4-7: Blocking R/E Valve Vent Port

3. STANDARD RESERVOIR *Slowly* pressurize the Reservoir by adjusting the oxygen source regulator. Verify that the secondary relief valve opens (audible hiss) at 65-75 psig (449-518 kPa).

   UNIVERSAL RESERVOIR *Slowly* pressurize the Reservoir by adjusting the oxygen source regulator. Verify that the secondary relief valve opens (audible hiss) at 25-37 psig (173-255 kPa).

NOTE: If the secondary relief valve does not open within this range the first time, reduce the pressure in the Reservoir and repeat the test a second time. If it fails to open within the acceptable range the second time, replace the valve per Reservoir Service and Repair, Section 6.9.

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4. Disconnect the pressurizing fixture and open the Reservoir vent valve to reduce the pressure below 20 psig (138 kPa). **Remove the clamp blocking the R/E valve vent port.**

4.3.3 Pressure Indicator Test (Standard Reservoir Only)

The Reservoir pressure indicator is a bourdon tube pressure gauge that indicates the status of the pressure in the system upstream of the pressure regulator. The pressure indicator *does not* indicate the pressure at the Reservoir oxygen outlet. This test determines the accuracy of the pressure indicator.

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-2).

2. Slowly pressurize the Reservoir until the needle of the Reservoir pressure indicator lines up with the 20 psig mark. It may be necessary to tap on top of the indicator with your finger to assure that the indicator is operating properly. Verify that the reading on the pressurizing fixture gauge is 18-22 psig (124-152 kPa).

3. Slowly increase the Reservoir pressure until the needle of the pressure indicator lines up with the 40 psig mark. Verify that the reading on the pressurizing fixture gauge is 38-42 psig (262-290 kPa).

NOTE: If the pressure indicator readings are not within the acceptable range, verify the accuracy of the test gauge. Replace the indicator, if required, per Reservoir Service and Repair, Section 6.4.

4.3.4 Pressure Regulator Test (Standard Reservoir Only)

The adjustable pressure regulator reduces the pressure of the oxygen gas leaving the HELiOS Reservoir oxygen outlet to a constant 22 psig (152 kPa). The regulator ensures that the Reservoir outlet pressure stays nearly constant despite changes in the inlet pressure and changes in downstream flow requirements. This test determines if the pressure regulator maintains oxygen outlet pressure within its acceptable range.

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-2).

2. Slowly increase the pressure in the Reservoir to 40 psig (276 kPa).

3. Attach an oxygen wye outlet adapter with two DISS demand check valve outlets to the Reservoir DISS oxygen outlet. Attach an external 22 psig (152 kPa) flow control valve (P/N B-701655-00) to one of the wye outlets. Attach a test pressure gauge with tubing adapter (Figure 1-18) to the other wye outlet (Figure 4-8).

4. Set the 22 psig (152 kPa) external flow control valve to 0. Verify that the test pressure gauge connected to the wye outlet reads 20.5-23.5 psig (141-162 kPa). Set the 22 psig (152 kPa) external flow control valve to 4 L/min. Verify that the test pressure gauge connected to the wye outlet still reads 20.5-23.5 psig (141-162 kPa). If the pressure reading is not within the acceptable range, perform the pressure regulator adjustment procedure per Reservoir Service and Repair, Section 6.12.4.

NOTE: Before making any pressure regulator adjustments because of low outlet pressure, verify that the perceived pressure problem is not the result of 1) another functional problem that may be creating low Reservoir system pressure or 2) a blockage that may be restricting flow into the regulator.

Figure 4-8: Pressure Regulator Test Setup

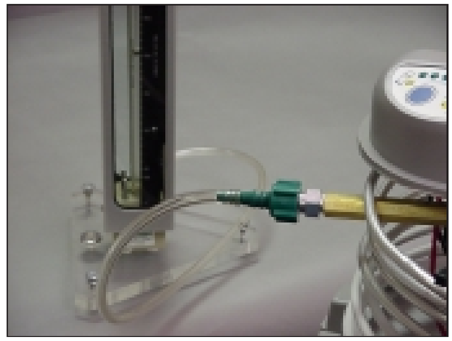
4.3.5 Flow Restrictor Test

A flow restrictor connector is installed in the pressure regulator inlet port on the Standard Reservoir or in the oxygen outlet mounting block inlet port on the Universal Reservoir. It limits the maximum flow through the regulator and oxygen outlet. This safety device prevents an abnormally high flow demand from overcoming the heat exchange capacity of the warming coil and causing a discharge of liquid oxygen. This test verifies the presence of a maximum flow restrictor.

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-2).

NOTE: The following steps require the use of a 0-40 L/min test flowmeter. If a 0-40 L/min test flowmeter is not available, remove the warming coil tube from the flow restrictor connector at the inlet of the pressure regulator (Standard Reservoir) or at the inlet of the oxygen outlet mounting block (Universal Reservoir). Verify that the sintered brass restrictor is present and unobstructed in the connector. Replace the flow restrictor connector as needed. Reconnect the tube and leak check the connection.

2. Use a length of 3/16-in. ID flexible tubing to connect a 0-40 L/min test flowmeter to a tubing barb adapter. Connect the flowmeter to the oxygen outlet (Figure 4-9).



Standard Reservoir Shown

Figure 4-9: Flow Restrictor Test Setup

3. STANDARD RESERVOIR Slowly increase the pressure in the Reservoir to 40 psig (276 kPa). Verify that the flowmeter reads less than 35 L/min. Reduce the Reservoir pressure to 24 psig (166 kPa). Verify that the flowmeter reads at least 15 L/min. Replace the flow restrictor connector as needed.

   UNIVERSAL RESERVOIR Slowly increase the pressure in the Reservoir to 24 psig (166 kPa). Verify that the flowmeter reads less than 35 L/min. Reduce the Reservoir pressure to 20 psig (138 kPa). Verify that the flowmeter reads at least 10 L/min. Replace the flow restrictor connector as needed.

4.4 LIQUID OXYGEN FUNCTIONAL TESTS

Conduct the following tests on a Reservoir that contains properly saturated liquid oxygen.

4.4.1 Contents Indicator Test

The contents indicator is an electronic, battery operated device that measures and displays the approximate amount of liquid oxygen in the Reservoir. It determines liquid oxygen contents by sensing the pressure created by the weight of the liquid oxygen in the container. Functional components include an 8-LED display panel, a low contents LED, a low battery LED, and a RJ 45 jack for optional remote contents monitoring. This test verifies that the electronic circuit is operational and that the pressure sense tubes are clear.

1. Verify that the yellow, low battery LED is off. Replace the 9-volt battery if needed.

2. Press the blue button on the contents indicator and verify that the yellow, low contents LED lights when the liquid oxygen contents is 8.5 lbs (3.9 kg) or less.

3. Fill the Reservoir so that it contains 20 to 25 lbs (9 to 11 kg) of liquid oxygen.

NOTE: If you plan on performing the Normal Evaporation Rate (NER) Test following this test, fill the Reservoir so that it contains 20 to 25 lbs (9 to 11 kg) of liquid oxygen saturated as close to primary relief valve pressure as possible. This may require you to partially close the Reservoir vent valve during the fill.

4. After five minutes, press the blue button and verify that the number of green LEDs lit on the the display correspond to the information in Table 4-1. The yellow, low contents LED should be off.

NOTE: If the Teleview remote monitoring option is connected to the contents indicator, refer to the Teleview technical manual for performance verification procedures.

NOTE: If step 4 fails, purge the container liquid sense tube per Reservoir Service and Repair, Section 6.15. If step 4 fails after purging the container liquid sense tube, replace the contents indicator per Reservoir Service and Repair, Section 6.3.

TABLE 4-1: CONTENTS INDICATOR DISPLAY STATES

Contents Indicator		H-36/H-46 Reservoir
No. of Green LEDs On	Yellow LED Status	Weight of LOX **Lb.** (kg)
0	On	**0.0-8.5** (0.0-3.9)
1	Off	**8.5-18.2** (3.9-8.3)
2	Off	**18.2-28.0** (8.3-12.7)
3	Off	**28.0-37.6** (12.7-17.1)
4	Off	**37.6-47.4** (17.1-21.5)
5	Off	**47.4-57.1** (21.5-25.9)
6	Off	**57.1-66.8** (25.9-30.0)
7	Off	**66.8-76.5** (30.3-34.7)
8	Off	**> 76.5** (34.7)

4.4.2 Normal Evaporation Rate (NER) Test

The NER test measures the insulation efficiency of the HELiOS Reservoir liquid oxygen container. The test results express in pounds (kilograms) the amount of liquid oxygen lost (converted into gaseous oxygen and vented through the relief valve) in a 24-hour period. Perform this test when one or more of the following symptoms exist:

a) Rapid loss of liquid oxygen contents from the container.
b) Heavy condensation or frost on the container.
c) Excessive venting of gaseous oxygen through the relief valve.

NOTE: Some venting of gaseous oxygen through the relief valve is normal.

1. Perform a leak test on the unit (Section 4.2) and verify that the results are acceptable.

2. Fill the unit with 20 to 25 lbs (9 to 11 kg) of liquid oxygen *saturated* as close to primary relief valve pressure as possible. Before continuing, allow the unit to sit undisturbed and stabilize for a minimum of 24 hours.

NOTE: The 24-hour stabilization period is critical to the NER test. Failure to allow for the stabilization period will yield inaccurate test results.

NOTE: The primary relief valve must be venting within the acceptable pressure range of 42 to 48 psig (290 to 331 kPa) for the Standard Reservoir or 24 to 28 psig (166-193 kPa) for the Universal Reservoir before starting NER test measurements.

3. After the stabilization period, start the test by recording the initial weight, pressure and time.

4. After an additional, minimum time of 24 hours, stop the test by recording the final weight, pressure, and time.

5. Calculate the NER using the following formula:

$$\text{NER (lb./day)} = \frac{\text{24 (hr/day) x Weight Loss (lbs.)}}{\text{Elapsed Time (hr)}}$$

6. Verify that the NER is 1.5 lb./day (0.68 kg/day) or less.

NOTE: If the NER is not within specification, allow the unit to stand for an additional 24 hours and recalculate the NER for this longer period of time before returning the unit for repair.

4.4.3 Economizer Test

The economizer valve establishes an operating pressure that allows a patient to breathe gas that would otherwise vent to atmosphere through the primary relief valve. Oxygen flow through the DISS oxygen outlet must occur to establish the economizer operating pressure. The economizer valve is part of the relief/economizer (R/E) valve. This test verifies that the economizer valve maintains Reservoir operating pressure within the acceptable range.

1. Verify that the Reservoir contains at least 20 lbs (9 kg) of liquid oxygen. If not, fill the unit with 20 to 25 lbs (9 to 11 kg) of liquid oxygen.

2. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-1).

3. STANDARD RESERVOIR To begin the test, the pressurizing fixture gauge should read 34-36 psig (235-248 kPa). If the gauge reading is higher, open the Reservoir vent valve to reduce the pressure. If the gauge reading is lower, allow time for the saturation pressure to increase to 34-36 psig (235-248 kPa).

   UNIVERSAL RESERVOIR To begin the test, the pressurizing fixture gauge should read 24-28 psig (166-193 kPa). If the gauge reading is lower, allow time for the saturation pressure to increase to 24-28 psig (166-193 kPa).

4. Attach a 22 psig (152 kPa) external flow control valve (P/N B-701655-00) to the Reservoir DISS oxygen outlet and set a continuous flow of 4 L/min.

NOTE: To test the economizer valve function, the Reservoir must be delivering a flow.

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5. With the unit delivering an oxygen flow, record the pressure readings on the pressurizing fixture gauge every hour until the pressure stabilizes. Stabilization occurs when two consecutive readings are within 1 psig (7 kPa) of each other.

   STANDARD RESERVOIR The acceptable operating range for the economizer valve is 24-30 psig (166-207 kPa). If the pressure reading is not within this range, adjust the economizer valve per Reservoir Service and Repair, Section 6.8.3.

   UNIVERSAL RESERVOIR The acceptable operating range for the economizer valve is 20.5-23.5 psig (141-162 kPa). If the pressure reading is not within this range, adjust the economizer valve per Reservoir Service and Repair, Section 6.8.3.

Section 5

RESERVOIR TROUBLESHOOTING

Table 5-1 provides troubleshooting procedures for the HELiOS Reservoir. This guide is not all-inclusive but is intended to serve as a general outline for solving operational problems. The table describes symptoms, identifies probable causes, and suggests corrective actions.

When more than one probable cause is identified, the causes are listed in order of most likely to least likely reasons for the problem.

Table 5-1

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Liquid oxygen leaks from fill connector after fill.	a. Ice crystal preventing proper closure of poppet.	a. If minor leak, engage and disengage mating fill connectors several times to dislodge ice crystal. If this fails, or if major leak, vent pressure in Reservoir to stop leak.
	b. Damaged poppet or fill connector.	b. Examine poppet and fill connector. If damaged, replace cartridge assembly or fill connector per Section 6.6.
2. Liquid oxygen leaks from engaged fill connectors during fill.	a. Teflon lip seal in female fill connector cracked or damaged.	a. Replace lip seal per Section 12.4.
3. Unable to disconnect transfer line (or Portable) from Reservoir after fill.	a. Fill connectors frozen together due to presence of moisture.	a. Close liquid valve on source tank (or vent valve on Portable) and allow transfer line (or Portable) to sit until fill connectors are warm enough to disconnect. (Fill connectors should be dried with lint-free cloth before filling.)
4. Excessively long fill time for fill technique used (standard or fast-fill).	a. Vent valve not fully open.	a. Rotate vent wrench counterclockwise until it stops.
	b. Liquid oxygen in source tank not at 40-50 psig (276-345 kPa) saturation pressure (standard fill); 24-28 psig (166-193 kPa) saturation pressure w/50 psig (345 kPa) pressure builder head (fast-fill).	b. Allow liquid oxygen to saturate to proper pressure; verify pressure builder working properly.
	c. Fill connector not opening properly.	c. Check fill connector and cartridge assembly for damage; make sure fill conectors fully engage.

Table 5-1 (cont.)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
5. Low pressure reading on Standard Reservoir pressure indicator (pressure reads less than 24 psig (166 kPa)).	a. Vent valve not completely closed or leaking. b. Reservoir filled with liquid oxygen at incorrect saturation pressure. c. Leak at plumbing connection. d. Damaged pressure indicator. e. Economizer valve stuck in open state (problem noticeable only during oxygen flow demand).	a. Close vent valve. Leak test valve outlet and stem. Replace or repair per Section 6.7. b Perform Resaturating Liquid Oxygen procedure in Section 2.5.7. c. Perform leak test in Section 4.2.1. d. Perform Pressure Indicator Test in Section 4.3.3. e. Perform economizer test in Section 4.4.3.
6. Low pressure at Reservoir oxygen outlet (pressure is less than 20.5 psig (141 kPa)).	a. Vent valve not completely closed or leaking. b. Reservoir filled with liquid oxygen at incorrect saturation pressure. c. Leak at plumbing connection. d. Economizer valve stuck in open state (problem noticeable only during oxygen flow demand). e. Standard Reservoir pressure regulator out of adjustment.	a. Close vent valve. Leak test valve outlet and stem. b. Perform Resaturating Liquid Oxygen procedure in Section 2.5.7. c. Perform leak test in Section 4.2.1. d. Perform economizer test in Section 4.4.3. e. Test pressure regulator per Section 4.3.4. Adjust regulator per Section 6.12.
7. High pressure reading on Standard Reservoir pressure indicator (pressure is greater than 48 psig (331 kPa)).	a. Primary relief valve setting too high or relief valve operating improperly. b. Container vacuum loss. c. Damaged pressure indicator.	a. Perform primary relief valve test in Section 4.3.1. Adjust or replace R/E valve per Section 6.8.3. b. Perform NER test in Section 4.4.2. c. Perform Pressure Indicator Test in Section 4.3.3.
8. High pressure at Reservoir oxygen outlet.	a. Universal Reservoir primary relief valve setting too high or relief valve operating improperly (no flow condition). b. Universal Reservoir economizer valve stuck in closed state (problem noticeable only during oxygen flow demand). c. Container vacuum loss. d. Standard Reservoir pressure regulator out of adjustment or malfunctioning.	a. Perform primary relief valve test in Section 4.3.1. Adjust or replace R/E valve per Section 6.8.3. b. Perform economizer test in Section 4.4.3. c. Perform NER test in Section 4.4.2. d. Test pressure regulator per Section 4.3.4. Adjust regulator per Section 6.12.

Table 5-1 (cont.)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
9. Low flow at oxygen outlet.	a. Low pressure at oxygen outlet. b. Partial obstruction of flow restrictor connector. c. Partial obstruction in liquid withdrawal tube or warming coil.	a. See Symptoms 5 and 6. b. Clean or replace flow restrictor connector. c. Check liquid withdrawal tube and warming coil for blockage. Clean or replace as needed. NOTE: Be aware of a non-removable twisted copper wire inserted into warming coil near its inlet.
10. No flow at oxygen outlet.	a. Reservoir is empty. b. Zero head pressure caused by major leak (vent valve open, relief valve malfunction, etc.) c. Total obstruction in liquid withdrawal tube, warming coil, flow restrictor connector, or pressure regulator.	a. Fill unit with liquid oxygen saturated at 24 psig (166 kPa). b. Locate leak and repair as needed. c. Locate obstruction and clean or replace components as needed.
11. Contents indicator reads incorrectly.	a. Battery voltage low. b. Leak in sensing tubes or fittings. c. Flexible contents indicator pressure sense tube pinched. d. Ice blockage in contents indicator (liquid) pressure sense tube. e. Contents indicator electronics malfunction.	a. Replace 9-volt battery. b. Perform leak test in Section 4.2.1. Repair as needed. c. Visually inspect flexible pressure sense tubes and remove pinching condition. d. Perform contents indicator liquid sense tube purge procedure in Section 6.15. e. Replace contents indicator module.
12. High product loss rate.	a. Container vacuum loss. b. Leak in tubing or connections.	a. Perform NER test in Section 4.4.2. b. Perform leak test in Section 4.2.1. Repair as needed.

Section 6

RESERVOIR SERVICE AND REPAIR

This section provides procedures for servicing the individual components of the Reservoir. Included are instructions, where applicable, for removal, disassembly, operational check, cleaning, inspection, adjustment, reassembly, and installation.

WARNING

Personal injury can occur from the uncontrolled release of pressurized gaseous and liquid oxygen. Empty liquid oxygen contents and vent system pressure before servicing.

WARNING

Injury to eyes from flying objects possible. Wear eye protection when servicing the Reservoir.

After removing a component, visually inspect for damage or any other indication that the part should be replaced. Unless otherwise specified, replace as needed with a new part. Refer to the Reservoir exploded view illustrations and parts list in Section 7.

NOTE: After making repairs, always verify proper system operation by performing the Reservoir functional tests in Section 4.

6.1 EMPTYING A RESERVOIR UNIT

The liquid oxygen in a Reservoir must be removed and the pressure vented to atmosphere before disassembling the unit for service. Also, the Reservoir oxygen contents must be removed before packaging and shipping the unit.

If time allows, empty the Reservoir by attaching a 22 psig (152 kPa) external flow control device that can deliver flows **not exceeding 10 L/min.** Place the Reservoir in a well ventilated location away from sources of ignition and pedestrian traffic. Set a flow and let the Reservoir run until it is empty. Remove the flow control device as soon as the Reservoir is empty.

You can empty the Reservoir more rapidly by transferring its liquid oxygen into an empty HELiOS or Companion Reservoir unit of equal or larger size. To empty a Reservoir in this way, perform the following procedure.

NOTE: Reservoir pressure should be at least 15 psig (104 kPa) to perform this procedure.

WARNING

Explosive hazard. Extremely high pressure can rupture the transfer line. Make sure the specified pressure relief valve is present, in the proper location, and functioning properly. After use, position the transfer line relief valve so that any liquid oxygen trapped in the line discharges in a safe direction as the line warms.

1. Attach an extra fill adapter assembly to the source adapter of the transfer line assembly (Figure 6-1).

2. Put on the personal protective gear (heavy gloves, face shield, etc.) used when filling the Reservoir with liquid oxygen.

3. Engage one fill adapter assembly to the Reservoir unit to be emptied (source). Engage the second fill adapter assembly to an empty Reservoir (receiver).

4. Open the vent valve on the receiver unit to begin the transfer process.

5. When the source unit is empty, venting from the receiver unit will diminish and eventually stop. Detach the transfer line assembly from each unit once the frost on the transfer line hose begins to melt.

NOTE: A small amount of liquid oxygen will remain in the Reservoir since the fill tube does not go all the way to the bottom of the container. This liquid oxygen will evaporate and build pressure. Open the Reservoir vent valve to vent the pressure.

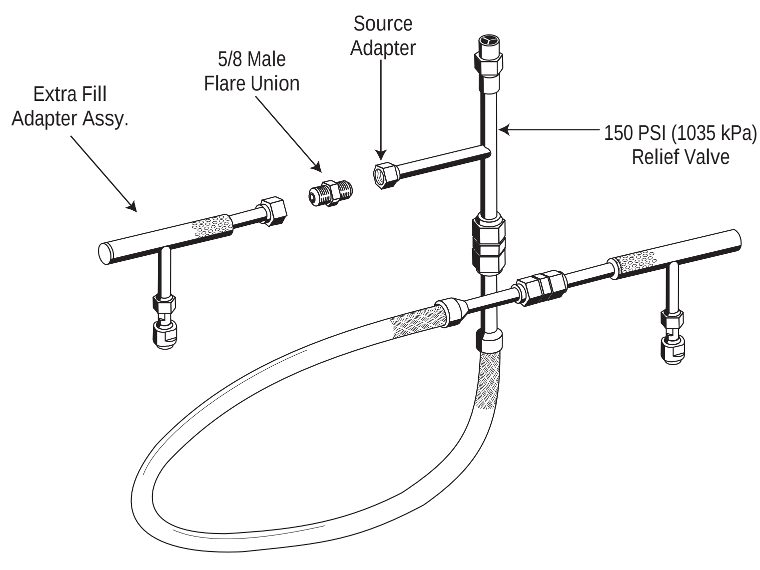


FIGURE 6-1: Transfer Line Configuration for Emptying a HELiOS Reservoir

6.2 SHROUD ASSEMBLY

The Reservoir unit's shroud assembly includes an upper shroud and a lower shroud. Both components are molded from an impact resistant plastic and protect the plumbing components on top of the unit.

6.2.1 Upper Shroud Removal

1. Remove the two pan head screw from the topside of the upper shroud.

2. Carefully remove the upper shroud by lifting it up and over the plumbing components.

6.2.2 Upper Shroud Service

Service to the upper shroud consists only of replacing the front warning label, the fill connector label, the oxygen diamond label**,** and the oxygen outlet warning label.

NOTE: New labels must be installed any time the upper shroud is replaced. Make sure that the front warning label is the correct one for the model of Reservoir it is to be used on.

6.2.3 Upper Shroud Installation

Install the upper shroud by reversing the removal procedure.

NOTE: Be sure to align the upper shroud so that the access holes are positioned directly over the corresponding Reservoir plumbing components. Also, be sure that the upper shroud is seated uniformly on the lower shroud lip.

6.2.4 Lower Shroud Removal

1. Remove the upper shroud (Section 6.2.1).

2. Slide the press-on tubing clamp back and disconnect the flexible black (gas) pressure sense tube from the barbed fitting on the R/E valve. Refer to Contents Indicator, Section 6.3 and note the warnings and cautions. Disconnect the flexible red (liquid) pressure sense tube from the "liquid" pressure sense barbed fitting (marked "HI") on the contents indicator.

3. While using a 9/16-in. open end wrench to hold the liquid withdrawal tee stationary, use a second 9/16-in. open end wrench to remove the warming coil compression nut from the tee. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.

4. Use a 5/32-in. hex key wrench to remove the four socket head cap screws that secure the mounting bracket to the manifold flange. Remove the mounting bracket and attached components.

5. Use a ¾-in. open-end wrench to remove the vent valve from the threaded manifold extension tube. Place the wrench on the valve hex flats closest to the manifold extension tube to prevent disassembly of the valve.

6. Use a 9/16-in. open end wrench to remove the economizer tube compression nut from the liquid withdrawal tee. Use a ½-in. open end wrench to remove the economizer tube inverted compression nut from the R/E valve. Remove the economizer tube.

7. Use a ¾-in. open-end wrench to remove the R/E valve assembly from the threaded manifold extension tube.

8. Remove the umbrella seal by carefully working it up over the manifold flange and tubes.

9. Remove the lower shroud by carefully working it up over the manifold flange and tubes.

6.2.5 Lower Shroud Installation

1. Install the lower shroud over the manifold flange and tubes. Pull the red flexible contents indicator tube up through the 3/16 in. (0.5 cm) diameter hole in the lower shroud tray (not the larger moisture drain hole). On early version lower shrouds without the 3/16 in. (0.5 cm) hole, pull the red flexible contents indicator tube up through the oval opening in the center of the shroud. Position the red tube in the notch molded into the side of the oval opening in the center of the shroud.

2. Position the embossed 1-in. (2.5-cm) circular index mark on the top of the lower shroud directly over the vacuum port on the container. Ensure that the container vacuum port is captured between two parallel vertical ribs on the bottom of the lower shroud. Use a flashlight and look to the right through the moisture container opening to verify capture of the vacuum port.

3. Install the umbrella shield over the manifold flange and tubes. Pull it down the neck of the container until it sits snugly over the oval opening in the center of the lower shroud. On early version lower shrouds without the 3/16 in. (0.5 cm) hole, make sure that the red, flexible contents indicator tube comes out of the oval opening in the center of the shroud and is underneath the umbrella seal.

4. Apply Teflon tape sealant to the threaded manifold tube facing the embossed circular index mark on the top of the lower shroud. Install the R/E valve assembly on the manifold tube and tighten so that the secondary relief valve is in a vertical, up position.

5. Install the end of the economizer tube with the inverted compression nut in the bottom port of the R/E valve. Install the opposite end of the economizer tube in the side port of the liquid withdrawal tee. Make sure both tube ends are aligned properly and then tighten both compression nuts.

6. Apply Teflon tape sealant to the threaded manifold tube opposite the R/E valve. Install the vent valve on the manifold tube with the valve flow direction arrow pointing away from the manifold. Tighten so that the valve stem is in a vertical, up position.

7. Position the mounting bracket with attached components over the manifold so that the release lever is over the R/E valve. Carefully insert the Teflon liquid withdrawal tube into the open end of the aluminum warming coil tube. Be careful not to kink or scrape the Teflon tube. Align the warming coil tube in the liquid withdrawal tee port and finger tighten the compression nut.

8. Align the mounting bracket on the manifold flange. Install the four socket head cap screws and tighten with a 5/32-in. hex key wrench. Tighten the warming coil compression nut using two 9/16-in. open-end wrenches.

9. Connect the flexible black (gas) pressure sense tube from the contents indicator “LO” circuit to the barbed fitting on the R/E valve. Slide the press-on tubing clamp onto the barbed fitting. Connect the flexible red (liquid) pressure sense tube from the container sense line to the “liquid” pressure sense fitting on the contents indicator. The “liquid” pressure sense fitting is marked “HI” and is located closest to the rear of the contents indicator module.

10. Install the upper shroud.

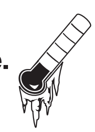
6.3 CONTENTS INDICATOR

The contents indicator measures the amount of liquid oxygen in the Reservoir. An electronic transducer senses a differential pressure proportional to the height of the liquid oxygen in the container. A panel of eight LEDs provide liquid oxygen level indication. An RJ 45 jack provides an interface for a remote contents monitoring option.

6.3.1 Removal

WARNING

Extreme cold hazard. Liquid oxygen discharge can occur from the contents indicator red (liquid) pressure sense tube. Remove all liquid oxygen contents (Section 6.1) and vent system pressure before servicing.



1. Remove the upper shroud (Section 6.2).

2. Lift the contents indicator module off of the mounting bracket and carefully turn it over.

CAUTION: Damage to contents indicator or barbed fittings can occur. Vent Reservoir pressure before removing either contents indicator tube. Use care when removing flexible tubes from barbed fittings on contents indicator. To remove, carefully cut tubes as close to end of barbed fittings as possible. Use razor blade to cut away tubing remnants remaining on barbed fittings.

3. Remove the flexible black (gas) pressure sense tube from the barbed fitting (“LO”) on the contents indicator.
4. Remove the flexible red (liquid) pressure sense tube from the barbed fitting (“HI”) on the contents indicator.

6.3.2 Service

The contents indicator is not field serviceable except for replacement of the 9-volt battery. To replace the battery, perform the following steps.

1. Insert a coin into the battery door slot at the rear of the contents indicator module.

2. Lift the coin up to remove the door.

3. Carefully disengage the battery from the battery clip.

4. Install a new 9-volt alkaline battery, taking care to observe proper battery polarity (Figure 6-2).

5. Make sure the battery wires are positioned in the bottom of the battery compartment. Position the battery door over the battery and push down until it snaps in place.

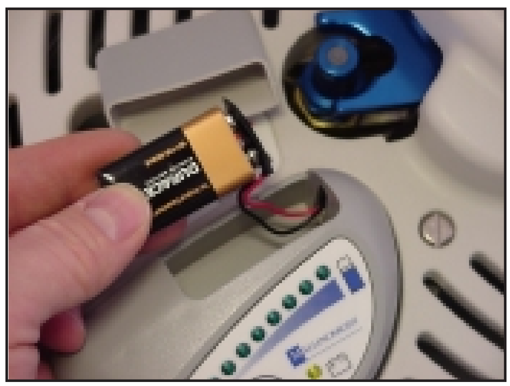


Figure 6-2: 9-volt Battery Installation

6.3.3 Installation

CAUTION: The contents indicator can read incorrectly. Do not pinch or kink the pressure sense tubes when installing the contents indicator. Do not cross-connect the pressure sense tubes. The red (liquid) pressure sense tube connects the barbed fitting nearest the rear of the contents indicator (marked “HI”) to the barbed fitting on the container stainless steel sensor tube. The black (gas) pressure sense tube connects the barbed fitting nearest the front of the contents indicator (marked “LO”) to the tee connecting the pressure indicator and the R/E valve (Figure 6-3).

Install the contents indicator by reversing the removal procedure.

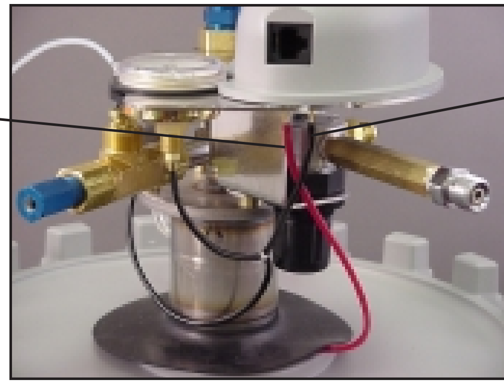


Figure 6-3: Contents Indicator Pressure Sense Tube Routing (Standard Reservoir Shown)

6.4 PRESSURE INDICATOR (STANDARD RESERVOIR ONLY)

The pressure indicator is a 0-100 psig (0-7 bar) bourdon tube pressure gauge that indicates the status of the pressure in the system upstream of the pressure regulator. **The pressure indicator does not indicate the pressure at the Reservoir oxygen outlet.**

6.4.1 Removal

1. Remove the upper shroud (Section 6.2).
2. Carefully pull the pressure indicator up and out of the grommet in the mounting bracket.
3. Slide the press-on tubing clamp back and disconnect the flexible black (gas) pressure sense tube from the barbed fitting on the pressure indicator.
4. Use a ¼-in. open-end wrench to remove the barbed fitting from the pressure indicator.

6.4.2 Service

Service to the pressure indicator consists of replacing the barbed fitting and replacing the lens. If the pressure indicator grommet needs to be replaced, install the grommet in the mounting bracket with the thin top lip of the grommet above the bracket.

6.4.3 Installation

Install the pressure indicator by reversing the removal procedure.

NOTE: Push the pressure indicator into the grommet until the bottom edge of the lens contacts the grommet lip. Position the indicator so that you can read it from the front of the Reservoir.

6.5 FILL CONNECTOR RELEASE ASSEMBLY

The fill connector release assembly disengages the female fill connector from the male fill connector upon completion of a fill. It consists of a release button and lever assembly.

NOTE: The Standard Reservoir release lever is different than the Universal Reservoir release lever. The levers are not interchangeable.

6.5.1 Removal

1. Remove the upper shroud (Section 6.2).
2. Use a needlenose pliers to remove one E-clip from the release lever pivot pin. Remove the pin from the release lever. Remove the lever from the mounting bracket.
3. Use a No. T10 Torx driver to remove two Torx screws from the release button. Remove the button from the lever.

6.5.2 Installation

Install the fill connector release assembly by reversing the removal procedure.

NOTE: Install the Standard Reservoir release lever with the rounded edges of the two fingers facing up.

6.6 MALE FILL CONNECTOR

The male fill connector is the male half of a fluid coupling system. The male connector, when engaged with a female connector, provides a means of transferring liquid oxygen to and from the Reservoir. The male connector consists of an anodized aluminum body, poppet cartridge assembly, and retainer ring.

CAUTION: Use care to prevent contaminants from entering container when removing fill connector. Do not nick or scratch tapered sealing surfaces of fill connector or ferrule.

6.6.1 Removal

1. Remove the upper shroud (Section 6.2).
2. Remove the fill connector release assembly (Section 6.5).
3. Use a 7/8-in. open-end wrench to hold the body of the fill connector stationary. Use a 10-in. adjustable wrench to loosen the compression nut on the fill connector. Remove the fill connector.

6.6.2 Inspection

1. Inspect the Kel-F poppet on the cartridge assembly for wear, damage, or embedded contaminants.

2. Inspect the fill connector body for wear or damage. Inspect the tapered sealing surface for embedded debris or scratches.

6.6.3 Service

Service to the male fill connector consists of replacing the fill connector assembly or replacing the cartridge assembly. To replace the cartridge assembly, follow the Disassembly procedure.

6.6.4 Disassembly

1. Use a small screwdriver or awl to remove the spiral retainer ring by first carefully lifting the beveled edge of the retainer over the lip of the retaining ring groove (Figure 6-4).

Figure 6-4: Removing the Retainer Ring

2. Carefully pry the rest of the ring over the lip until the entire ring pops out.

3. Remove the cartridge assembly (Figure 6-5).

Figure 6-5: Removing Cartridge Assembly and Retainer Ring

6.6.5 Reassembly

1. Insert the cartridge assembly into the fill connector body.

2. Insert the small opening end of the male installation sleeve (marked "M", P/N B-775393-00) into the threaded end of the fill connector body.

3. Place the spiral retainer ring into the open end of the male installation sleeve (Figure 6-6).

Figure 6-6: Inserting Retainer Ring into Male Installation Sleeve

4. Hold the male installation sleeve firmly against the body of the fill connector. Insert the rounded end of the inner installation tool (marked "I", P/N B-775392-00) into the male sleeve and push the retainer ring down until you feel it "click" into place (Figure 6-7).

Figure 6-7: Installing the Retainer Ring

6.6.6 Installation

Install the male fill connector on the Reservoir fill tube by reversing the removal procedure**. Be sure to hold the fill connector stationary while tightening the compression nut.**

NOTE: To ease the installation process, use a *small* amount of Krytox 240 AC on the threads of the fill connector. This helps lubricate the threads and makes tightening the connector easier.

6.7 VENT VALVE

The vent valve is a quarter turn ball valve that, when open, vents the Reservoir container to begin a fill. Closing the vent valve terminates the fill.

6.7.1 Removal

1. Remove the upper shroud (Section 6.2).

2. Use a 3/4-in. open-end wrench to remove the vent valve. Place the wrench on the valve hex flats closest to the manifold to prevent disassembly of the valve as you remove it.

6.7.2 Inspection

Inspect the valve stem O-ring and spring pin for wear or damage. Inspect the vent wrench stops on the valve body for wear or damage.

6.7.3 Service

Service to the Reservoir vent valve consists of replacing the valve stem spring pin, O-ring retainer ring, and/or valve stem O-ring. A vent valve with damaged wrench stops must be replaced. Leaks that occur around the valve stem can usually be corrected by a slight tightening of the valve stem packing nut. Pressurize the Reservoir with gaseous oxygen and apply leak detector to the valve stem and packing nut. Use a 7/16-in. open-end wrench to tighten the packing nut until leak detector bubbling just stops. Blow dry the valve stem and packing nut.

6.7.4 Disassembly

1. Use a 3/4-in. open-end wrench to hold the outer hex flats of the vent valve stationary while using a 9/16-in. open-end wrench to remove the vent extension.

2. Lightly clamp the vent valve in a vise.

3. Use a pin punch and a hammer to drive the spring pin out of the valve stem.

4. Use a small screwdriver to carefully pry the retainer ring off of the valve stem (Figure 6-8).

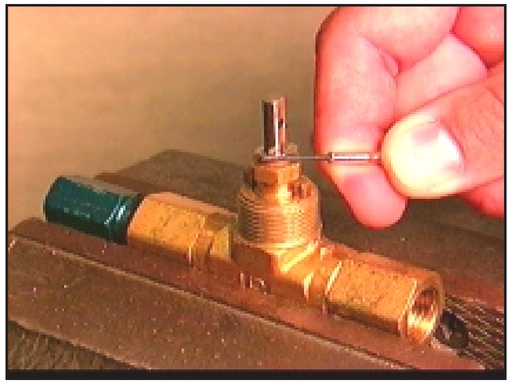


Figure 6-8: Removing the Retainer Ring from the Vent Valve

5. Use a dental pick or similar object to lift the O-ring off the valve stem (Figure 6-9).

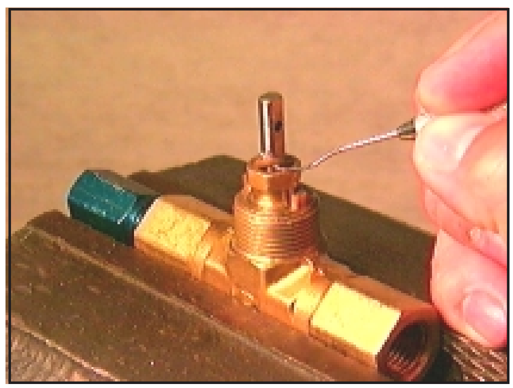


Figure 6-9: Removing O-ring from Vent Valve

6.7.5 Reassembly

Reassemble the vent valve by reversing the disassembly procedure.

6.7.6 Installation

NOTE: Before installing the vent valve, wrap the threaded manifold extension tube with Teflon tape starting two threads back from the end. Verify that the arrow on the vent valve body points away from the manifold.

Install the vent valve by reversing the removal procedure.

6.8 RELIEF/ECONOMIZER (R/E) VALVE

The relief/economizer (R/E) valve is a pressure regulating device that combines the function of a primary relief valve and an economizer valve into one component. The primary relief valve establishes the maximum operating pressure achievable in the Reservoir. The economizer valve establishes an operating pressure that allows a patient to breathe gas that would otherwise vent to atmosphere through the primary relief valve. The R/E valve is not field repairable. However, the R/E valve pressure settings may be adjusted if they are out of range.

6.8.1 Removal

1. Remove the upper shroud (Section 6.2).

2. Use a 5/8-in. open-end wrench to remove the secondary relief valve from the R/E valve.

3. Slide the press-on tubing clamp back and disconnect the flexible black (gas) pressure sense tube from the 1/16-in. barbed fitting on the R/E valve. Use a 1/4-in. open-end wrench to remove the 1/16-in. barbed fitting.

4. Use a ½-in. open-end wrench to remove the economizer tube assembly inverted compression nut from the R/E valve. Carefully pull the economizer tube down until it clears the R/E valve.

5. Use a ¾-in. open-end wrench to remove the R/E valve from the threaded manifold extension tube.

6.8.2 Installation

1. Apply Teflon tape sealant to the threaded manifold tube facing the embossed circular index mark on the top of the lower shroud. Install the R/E valve on the threaded manifold tube and tighten so that the secondary relief valve port is in a vertical, up position.

2. Install the end of the economizer tube with the inverted compression nut in the bottom port of the R/E valve. Make sure the tube end is aligned properly in the port and then tighten the inverted compression nut.

3. Install the 1/16-in. barbed fitting in the R/E valve port that faces the center of the Reservoir. Connect the flexible black tube and the tubing clamp to the barbed fitting.

⚠ CAUTION: High pressure hazard. Over tightening the secondary relief valve can cause it to operate improperly. Do not over tighten the valve. Perform Secondary Relief Valve Test in Section 4.3.2.

4. Apply Teflon tape sealant to the secondary relief valve threads. Install the secondary relief valve in the R/E valve port and tighten until snug.

5. Install the upper shroud.

6.8.3 R/E Valve Adjustment

If the primary relief valve or the economizer valve is operating at a pressure out of its acceptable range, it may be possible to adjust the setting of the valve. Carefully perform the following steps to adjust the pressure setting for the appropriate valve.

NOTE: Before making any R/E valve adjustments, verify that perceived pressure problems are not the result of other Reservoir functional problems.

Adjusting the Primary Relief Valve

1. Attach one end of a 1/8-in. I.D. flexible tube to the 1/8-in. barbed fitting at the R/E valve vent port. Insert the other end of the flexible tube into a clean jar of water (Figure 6-10).

(a)

(b)

Figure 6-10: Primary Relief Valve Test Setup

2. Connect a pressurizing fixture (P/N B-701731-00) to the fill connector on the empty Reservoir. Attach an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.

3. *Slowly* pressurize the Reservoir with gaseous oxygen by adjusting the oxygen source pressure regulator.

4. STANDARD RESERVOIR The pressurizing fixture gauge should read 42-48 psig (290-331 kPa) when a continuous stream of bubbles first appears in the jar of water.
   UNIVERSAL RESERVOIR The pressurizing fixture gauge should read 24-28 psig (166-193 kPa) when a continuous stream of bubbles first appears in the jar of water.

5. If the primary relief valve pressure is low, turn the primary relief valve adjustment screw a quarter turn clockwise (in) and repeat steps 3, 4, and 5. The primary relief valve adjustment screw is located on the pressure regulator side of the R/E valve (Figure 6-11).

6. If the primary relief valve pressure is high, reduce the pressure in the Reservoir to 40 psig (276 kPa) for the Standard Reservoir or to 22 psig (152 kPa) for the Universal Reservoir. Turn the primary relief valve adjustment screw a quarter turn counter clockwise (out) and repeat steps 3 through 6.

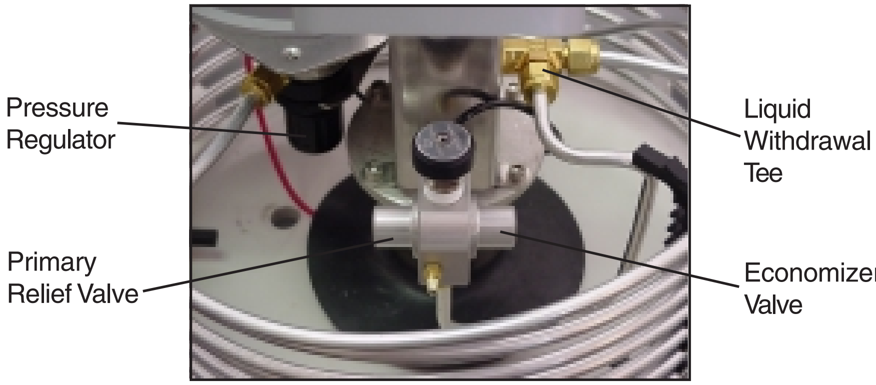


Figure 6-11: Primary Relief Valve and Economizer Adjustment (Standard Reservoir Shown)

Adjusting the Economizer Valve

7. STANDARD RESERVOIR Fill the Reservoir with about 20 lbs (9 kg) of liquid oxygen. Allow enough time for the liquid oxygen to reach a saturation pressure of 34-36 psig (235-248 kPa) or refer to Resaturating Liquid Oxygen, Section 2.5.7.
UNIVERSAL RESERVOIR Fill the Reservoir with about 20 lbs (9 kg) of liquid oxygen. Allow enough time for the liquid oxygen to reach a saturation pressure of 24-26 psig (166-179 kPa) or refer to Resaturating Liquid Oxygen, Section 2.5.7.

8. Attach a 22 psi (152 kPa) external flow control (P/N B-701655-00) to the Reservoir oxygen outlet and set a continuous flow of 4 L/min.

NOTE: To check the economizer adjustment the Reservoir must be delivering a flow.

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9. Momentarily connect the pressurizing fixture to the Reservoir fill connector to take a pressure reading. Record the reading.

10. With the Reservoir delivering a flow, record pressure readings every hour until the pressure stabilizes. Stabilization has occurred when two consecutive readings are within 1 psig (6.9 kPa) of each other.
STANDARD RESERVOIR The acceptable operating range for the economizer valve is 24-30 psig (166-207 kPa).
UNIVERSAL RESERVOIR The acceptable operating range for the economizer valve is 20.5-23.5 psig (141-162 kPa).

11. If the economizer pressure is low, turn the economizer valve adjustment screw a quarter turn *clockwise (in)*. If the economizer pressure is high, turn the economizer valve adjustment screw a quarter turn *counter clockwise (out)*. The economizer valve adjustment screw is located on the liquid withdrawal tee side of the R/E valve (Figure 6-11). A quarter turn adjustment of the screw typically changes the pressure about 1 psig (6.9 kPa).

NOTE: The Reservoir must continue to deliver flow when making economizer valve adjustments. After making an adjustment, record pressure readings every hour until the pressure stabilizes at the new economizer pressure setting. Repeat this step as needed to bring the economizer pressure within specifications.

6.9 SECONDARY RELIEF VALVE

The secondary relief valve is a poppet-type pressure control valve that acts as a safety backup in the event that the primary relief valve fails to limit system pressure to an acceptable range. Under normal operating conditions, the secondary relief valve remains closed. The secondary relief valve is not field serviceable or adjustable.

6.9.1 Removal

1. Remove the upper shroud (Section 6.2).

2. Use a 5/8-in. open-end wrench to remove the secondary relief valve from the R/E valve.

6.9.2 Installation

CAUTION: High pressure hazard. Over tightening the secondary relief valve can cause it to operate improperly. Do not over tighten the valve. Perform Secondary Relief Valve Test in Section 4.3.2.

1. Apply Teflon tape sealant to the secondary relief valve threads. Install the secondary relief valve in the R/E valve port and tighten until snug.

2. Install the upper shroud.

6.10 WARMING COIL

The Reservoir warming coil is a heat exchanger consisting of a loosely wound coil of ¼-in. aluminum tubing over 20 feet (6 meters) long. A non-serviceable internal copper twist wire improves the efficiency of the heat exchange process. The warming coil connects the liquid withdrawal tee to the pressure regulator.

6.10.1 Removal

1. Remove the upper shroud (Section 6.2).

2. Use a 9/16-in. open-end wrench to hold the flow restrictor connector stationary at the pressure regulator inlet (Standard Reservoir) or the outlet block inlet (Universal Reservoir). Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the flow restrictor connector. Carefully pull the warming coil tube out of the connector.

3. Use a 9/16-in. open-end wrench to hold the liquid withdrawal tee stationary. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the tee. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.

4. Push the warming coil assembly back toward the release lever. Rotate the warming coil to bring the far side up and over the release lever (Figure 6-12). Pull the near side of the warming coil forward to clear the oxygen outlet DISS fitting and vent valve extension.

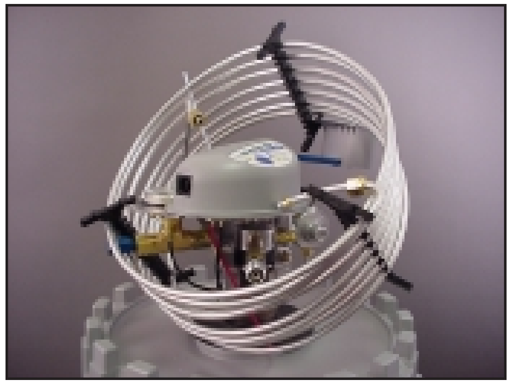

Figure 6-12: Removing the Warming Coil (Standard Reservoir Shown)

6.10.2 Installation

Install the warming coil by reversing the removal procedure.

CAUTION: Be careful not to kink or scrape the Teflon liquid with drawal tube when inserting it into the warming coil.

NOTE: The oxygen outlet DISS fitting should be between the first (top) and second warming coil tube. The vent valve extension should be between the second and third warming coil tube.

6.11 ECONOMIZER TUBE ASSEMBLY

The economizer tube assembly connects the R/E valve outlet to the liquid withdrawal tee. When a flow demand is present at the oxygen outlet and the economizer valve is open, gaseous oxygen from the Reservoir headspace flows through the economizer tube. As outlet flow demand continues, and headspace pressure decreases to the economizer valve setting, flow through the economizer tube drops to less than 1 L/min. Vaporized oxygen from the liquid withdrawal circuit makes up the balance of the flow demand.

6.11.1 Removal

1. Remove the upper shroud (Section 6.2).

2. Use a 9/16-in. open end wrench to remove the economizer tube assembly compression nut from the liquid withdrawal tee. Use a ½-in. open end wrench to remove the economizer tube assembly inverted compression nut from the R/E valve. Remove the economizer tube assembly.

6.11.2 Installation

NOTE: Before installing the economizer tube assembly, make sure a sintered element is present in the end of the tube that connects to the liquid withdrawal tee.

Install the economizer tube assembly by reversing the removal procedure.

6.12 PRESSURE REGULATOR (STANDARD RESERVOIR ONLY)

The adjustable pressure regulator reduces the pressure of the oxygen gas leaving the HELiOS Reservoir oxygen outlet to a constant 22 psig (152 kPa). The regulator ensures that the Reservoir outlet pressure stays nearly constant despite changes in the inlet pressure and changes in downstream flow requirements.

6.12.1 Removal

1. Remove the upper shroud (Section 6.2).
2. Remove the warming coil (Section 6.10).
3. Use a ½-in. open-end wrench to remove the DISS outlet extension from the regulator outlet.
4. Use a 9/16-in. open-end wrench to remove the flow restrictor connector from the regulator inlet.
5. Pull down on the regulator adjustment knob to release the knob locking mechanism.
6. Use a 10-in. arc-joint pliers to remove the serrated plastic retaining nut that secures the regulator to the mounting bracket.
7. Lift up on the regulator to allow the mounting bracket to pass between the regulator knob and bonnet as you remove it.

6.12.2 Service

The pressure regulator is not field serviceable. The regulator bonnet and body are permanently bonded together and the internal components are not accessible.

6.12.3 Installation

Install the pressure regulator by reversing the removal procedure.

NOTE: Apply Teflon tape sealant to the NPT threads of the DISS outlet extension and the flow restrictor connector before installing.

NOTE: Position the regulator so that the DISS outlet extension is parallel with the vertical back of the mounting bracket (Figure 6-13).

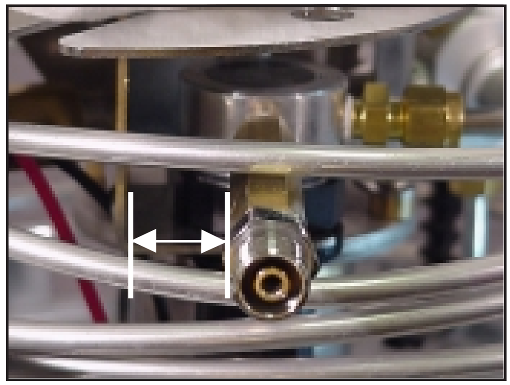

Figure 6-13: Positioning the Pressure Regulator

6.12.4 Adjustment

If the pressure regulator outlet pressure is not within its acceptable range, it may be possible to adjust the regulator setting. Carefully perform the following steps to adjust the pressure regulator setting.

NOTE: Before making any pressure regulator adjustments, verify that the perceived outlet pressure problem is not the result of 1) another functional problem that may be creating low Reservoir system pressure or 2) a blockage that may be restricting flow into the regulator.

1. Engage the pressurizing fixture (Figure 1-19) to the fill connector on the Reservoir and secure it with the attached strap (Figure 4-5). Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture (Figure 4-6).

2. Slowly increase the pressure in the Reservoir to 40 psig (276 kPa).

3. Attach an oxygen wye outlet adapter with two DISS demand check valve outlets to the Reservoir DISS oxygen outlet. Attach a 22 psig (152 kPa) external flow control valve (P/N B-701655-00) to one of the wye outlets. Attach a test pressure gauge with tubing adapter (Figure 1-18) to the other wye outlet (Figure 4-8). Set a 4 L/min flow on the 22 psig (152 kPa) external flow control valve.

4. Reach in from below the vent valve and grasp the pressure regulator adjustment knob. Pull the knob straight down until you hear it “click”. Turn the knob clockwise (looking at the regulator from the knob end) to increase the pressure. Turn the knob counter-clockwise to decrease the pressure. The pressure reading on the test pressure gauge should be 20.5-23.5 psig (141-162 kPa).

5. Once the pressure regulator setting is within specifications, push the knob up until you hear it “click”. This locks the adjustment.

6.13 OXYGEN OUTLET BLOCK (UNIVERSAL RESERVOIR ONLY)

The oxygen outlet block assembly consists of a ported aluminum block that contains the flow restrictor connector and the 9/16-18 DISS oxygen outlet fitting. The DISS oxygen outlet fitting contains a spring activated poppet valve. The poppet valve keeps oxygen from flowing through the outlet until needed. Attaching a mating DISS nut and tailpiece to the fitting opens the poppet valve and enables oxygen to pass through.

6.13.1 Removal

1. Remove the upper shroud (Section 6.2).
2. Use a 5/8-in. open-end wrench to remove the DISS fitting from the outlet block.
3. Use a 9/16-in. open-end wrench to hold the flow restrictor connector stationary at the oxygen outlet block inlet. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the flow restrictor connector. Carefully pull the warming coil tube out of the connector.
4. Use a 9/16-in. open-end wrench to remove the flow restrictor connector from the oxygen outlet block.
5. Lift the contents indicator off of the mounting plate and use a 5/32 in. hex key wrench to remove the flat head screw that fastens the oxygen outlet block to the mounting plate. Remove the oxygen outlet block.

6.13.2 Installation

Install the oxygen outlet block by reversing the removal procedure.

NOTE: Apply Teflon tape sealant to the NPT threads of the flow restrictor connector and the DISS fitting before installing.

6.14 CRYOGENIC CONTAINER

The Reservoir cryogenic container is a stainless steel, double-walled, vacuum-insulated container that holds liquid oxygen. The container's main function is to limit the amount of heat that leaks into the container from the surrounding atmosphere. The container is not field serviceable. Contact Puritan-Bennett Technical Support if you suspect a problem with the cryogenic container.

6.14.1 Removal

1. Remove the upper shroud and lower shroud (Section 6.2).
2. Remove the male fill connector (Section 6.6).
3. Use a 9/16-in. open-end wrench to remove the liquid withdrawal tee from the threaded manifold extension tube.

4. Carefully slide the tubing clamp away from the barbed fitting that connects the steel container sense tube to the flexible red (liquid) pressure sense tube. Disconnect the flexible red (liquid) pressure sense tube from the barbed fitting.

5. To prevent contaminants from entering the cryogenic container, place a clean plastic bag over the open manifold ports and seal tightly.

6.14.2 Installation

Install the cryogenic container by reversing the removal procedure.

NOTE: Apply Teflon tape sealant to the NPT threads on the manifold ports before installing components.

6.15 PURGING THE CONTAINER LIQUID SENSE TUBE

If the contents indicator is reading empty or low when the Reservoir unit is full, and there are no leaking fittings or connections, there may be an obstruction in the container liquid sense tube. The most common obstruction is the formation of ice crystals. Over a period of time, water may enter the system during the filling process. Once in the system, the water may become trapped in the container liquid sense tube. When the inner container cools to cryogenic temperatures, the water freezes and blocks the tube, causing the contents indicator to operate improperly. If this happens, follow the purging procedure listed below.

PROCEDURE

1. Before servicing the unit, empty the liquid oxygen contents from the Reservoir (Section 6.1).

2. Remove the upper shroud (Section 6.2).

3. Use the vent wrench to open the vent valve on the Reservoir unit.

4. Connect the pressurizing fixture (P/N B-701731-00) to the fill connector on the Reservoir unit. Attach an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the fixture (Figure 6-10).

5. Adjust the regulator until the gauge on the pressurizing fixture reads approximately 15 psig (103 kPa). With only the vent valve open, allow the system to purge for about 45 minutes.

6. Disconnect the pressurizing fixture.

7. **With no pressure in the unit,** disconnect both the flexible black (gas) pressure sense tube and the flexible red (liquid) pressure sense tube from the contents indicator (see Section 6.3). Using a wire tie, lightly secure the tubes to the vent valve to prevent them from moving around.

⚠ **CAUTION: Damage to the contents indicator can occur. Disconnect *both* contents indicator tubes before pressurizing the Reservoir. Vent the Reservoir before connecting or disconnecting indicator tubes.**

8. Close the vent valve. Reconnect the pressurizing fixture and adjust the regulator until the pressurizing fixture reads approximately 15 psig (103 kPa). Allow an additional 15 minutes for gas to flow through and purge the contents indicator tubes.

9. Disconnect the pressurizing fixture and open the Reservoir vent valve. Reconnect both pressure sense tubes to the contents indicator (see Section 6.3). Perform the contents indicator test (Section 4.4.1).

Section 7

RESERVOIR ILLUSTRATED PARTS LIST

Section 7 contains exploded view illustrations and related parts lists for the HELiOS Standard Reservoir and the HELiOS Universal Reservoir.

Part number and location information for the **HELiOS Standard Reservoir** is shown in Figures 7-1, 7-2, and 7-3.

Part number and location information for the **HELiOS Universal Reservoir** is shown in Figures 7-4, 7-5, and 7-6.

NOTE: Make sure to refer to the proper illustration and parts list for the model Reservoir that you are working on.

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FIGURE 7-1 PARTS LIST - HELiOS STANDARD RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701002-00	Screw, Pan Head – ¼-28 x 1¼-in. SS	2
2	B-701528-00	Label, Reservoir Fill Connector	1
3	B-701527-00	Label, Standard Reservoir Front Warning	1
4	B-701533-00	Label, Reservoir Oxygen Outlet Warning	1
5	B-701529-00	Label, Reservoir Oxygen Diamond	1
6	B-701544-00	Upper Shroud	1
7	B-701636-00	Warming Coil Assembly, Standard Reservoir, 1/4-in. O.D. Aluminum (includes item 8)	1
8	B-701550-00	Bracket, Warming Coil	1
9	B-701546-00	Moisture Container	1

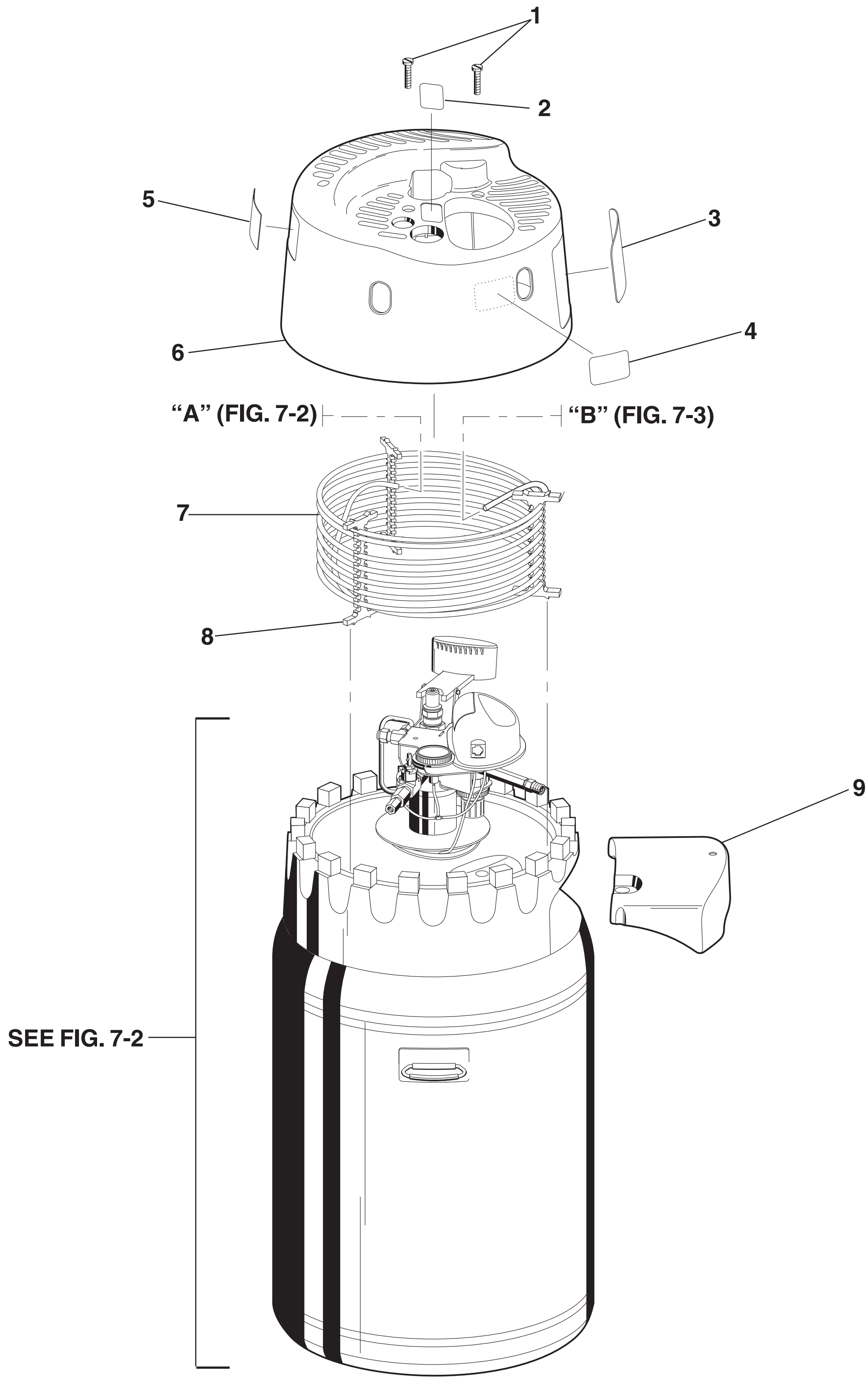


FIGURE 7-1
Standard Reservoir

FIGURE 7-2 PARTS LIST - HELiOS STANDARD RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701635-00	Screw, Socket Head Cap – 10-24 x 3/8-in.	4
2	B-701695-00	Tube, Black Flexible – 1/16-in. x 12-in.	1
3	B-775794-00	Clamp, 1/16-in. Flexible Tubing	2
4	B-778167-00	Fitting, Brass - 1/16-in. Barb x 10-32	1
5	B-776483-00	Relief Valve, Secondary, Standard Res. (70 psig)	1
6	B-778157-00	Fitting, Brass – 1/8-in. Barb x 10-32	1
7	B-701627-00	Relief/Economizer Valve, Standard Res. (45/27 psig)	1
8	B-701630-01	Economizer Tube Assy. w/ Nuts and Ferrules	1
9	B-775265-00	Nut, Brass – ¼-in. Tube	1
10	B-775063-00	Ferrule, Brass – ¼-in. Tube	1
11	B-701622-00	Tee, LOX Withdrawal – 1/8 NPT x ¼-in. Tube x ¼-in. Tube	1
12	B-776175-00	Spring	1
13	B-701590-00	Ferrule, Brass – 1/8-in	1
14	B-701739-00	O-ring	1
15	Reference	Tube, Teflon Withdrawal – 30-in.	1
16	B-701543-00	Lower Shroud	1
17	B-701626-00	Umbrella Seal	1
16	B-701694-00	Tube, Red Flexible – 1/16-in. x 15-in.	1
19	Reference	Cryogenic Container	1
20	B-701699-00	Extension, Vent Valve	1
21	B-775133-00	Vent Valve Assembly – (includes items 22, 23, 24)	1
22	B-775241-00	Retaining Ring	1
23	B-775285-00	O-ring	1
24	B-775136-00	Spring Pin – 3/32-in. x ½-in. SS	1
25	B-775322-00	Fill Connector, Male – (includes items 26, 27)	1
26	B-775259-00	Cartridge Assembly w/Retainer Ring	1
27	B-775267-00	Retainer Ring	1

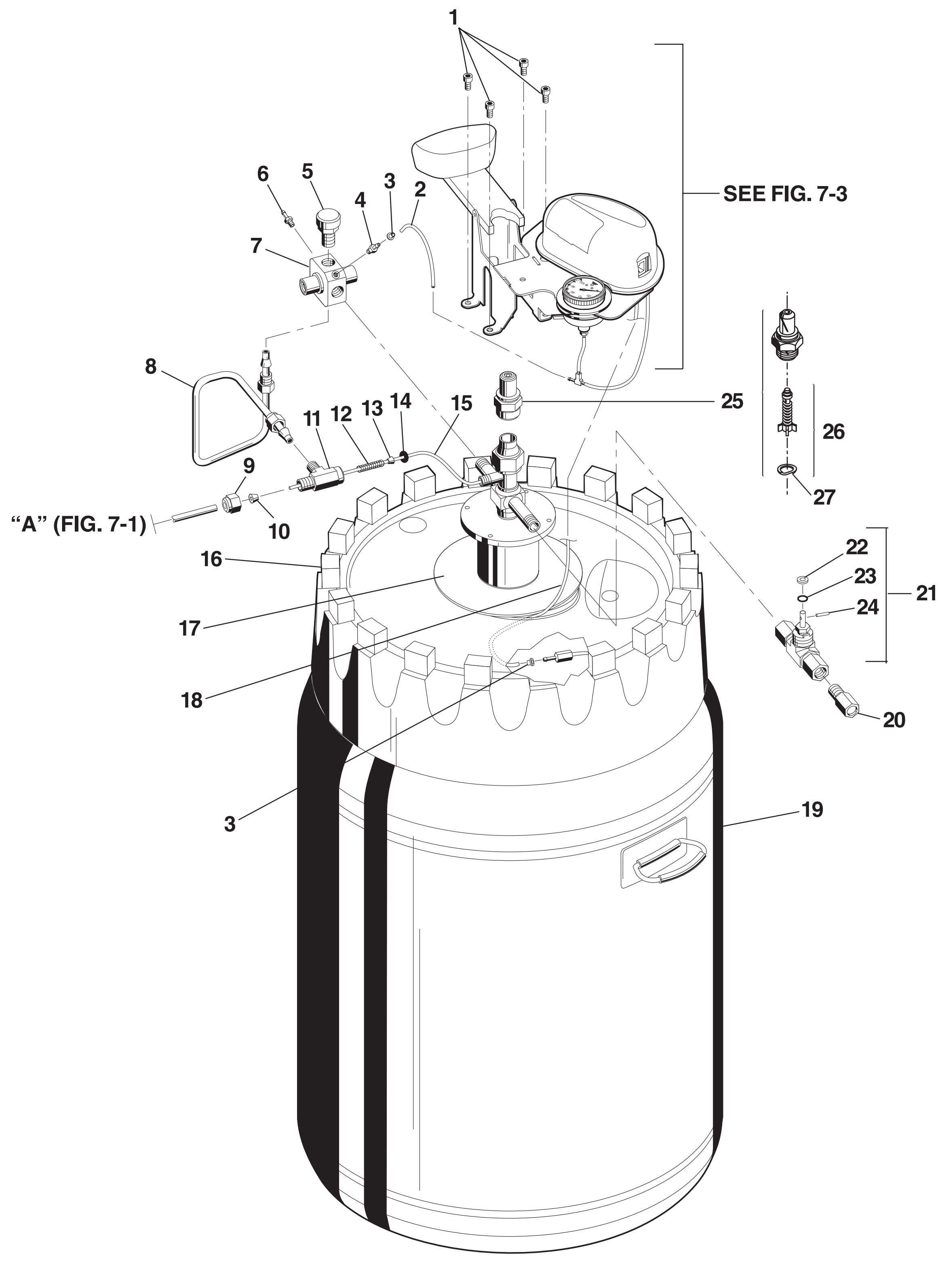


FIGURE 7-2
Standard Reservoir

FIGURE 7-3 PARTS LIST - HELiOS STANDARD RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701545-00	Release Button	1
2	B-701633-00	Release Lever, Standard Res.	1
3	B-701524-00	Screw, Torx Head, 8-16 x ¾-in.	2
4	B-777505-00	E-Ring	2
5	B-701634-00	Shaft, Pivot	1
6	B-701629-00	Connector, Flow Restrictor	1
7	B-775063-00	Ferrule, Brass – ¼-in. Tube	1
8	B-775265-00	Nut, Brass – ¼-in. Tube	1
9	B-701628-00	Regulator	1
10	B-701645-00	Extension, HELiOS DISS Outlet – 1/8 NPT	1
11	B-776997-00	DISS Fitting w/Poppet – 1/8 NPT x 9/16-18	1
12	B-701632-00	Bracket, Reservoir	1
13	B-701695-00	Tube, Black Flexible – 1/16-in. x 12-in.	1
14	B-701526-00	Tee, Barbed - 1/16-in. Flexible Tube	1
15	B-701583-00	Tube, Black Flexible – 1/16-in. x 3-in.	2
16	B-701694-00	Tube, Red Flexible – 1/16-in. x 15-in.	1
17	B-775794-00	Clamp, 1/16-in. Flexible Tubing	1
18	B-778167-00	Fitting, Brass - 1/16-in. Barb x 10-32	1
19	B-701640-00	Grommet, Pressure Indicator Mounting	1
20	B-702076-00	Gauge, Pressure Indicator (0-100 psi/0-7 bar)	1
21	B-778807-00	Lens, Pressure Indicator	1
22	B-494788-00	Contents Indicator Module –(includes items 23, 24)	1
23	B-492297-00	Battery, 9-Volt Alkaline	1
24	B-701523-00	Battery Door	1
25	B-701635-00	Screw, Socket Head Cap – 10-24 x 3/8-in.	4

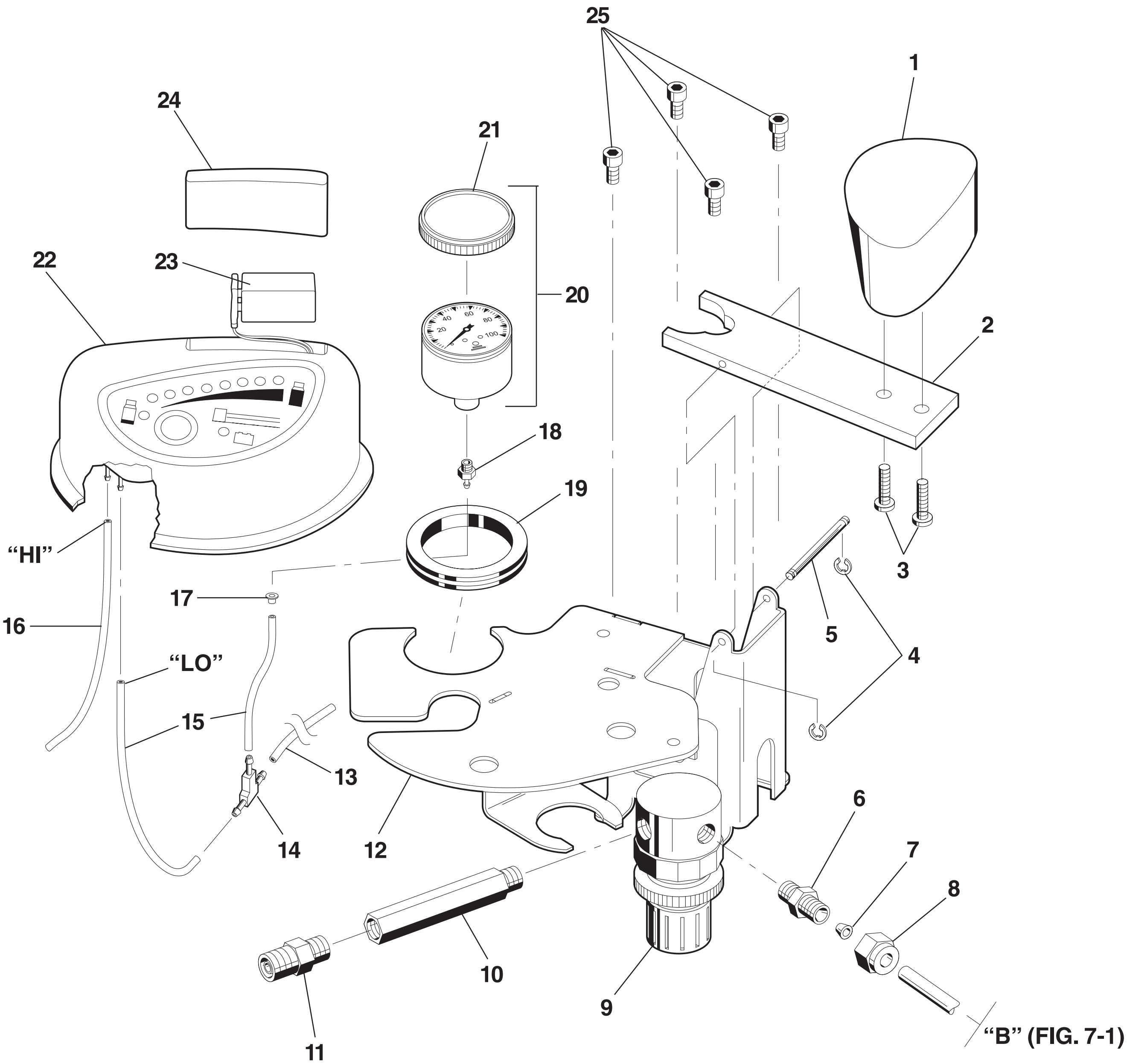


FIGURE 7-3
Standard Reservoir

FIGURE 7-4 PARTS LIST - HELiOS UNIVERSAL RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701002-00	Screw, Pan Head – ¼-28 x 1¼-in. SS	2
2	B-701528-00	Label, Reservoir Fill Connector	1
3	B-702104-00	Label, Universal Reservoir Front Warning	1
4	B-701533-00	Label, Reservoir Oxygen Outlet Warning	1
5	B-701529-00	Label, Reservoir Oxygen Diamond	1
6	B-701544-00	Upper Shroud	1
7	B-702107-00	Warming Coil Assembly, Universal Reservoir, 1/4-in. O.D. Aluminum (includes item 8)	1
8	B-701550-00	Bracket, Warming Coil	1
9	B-701546-00	Moisture Container	1

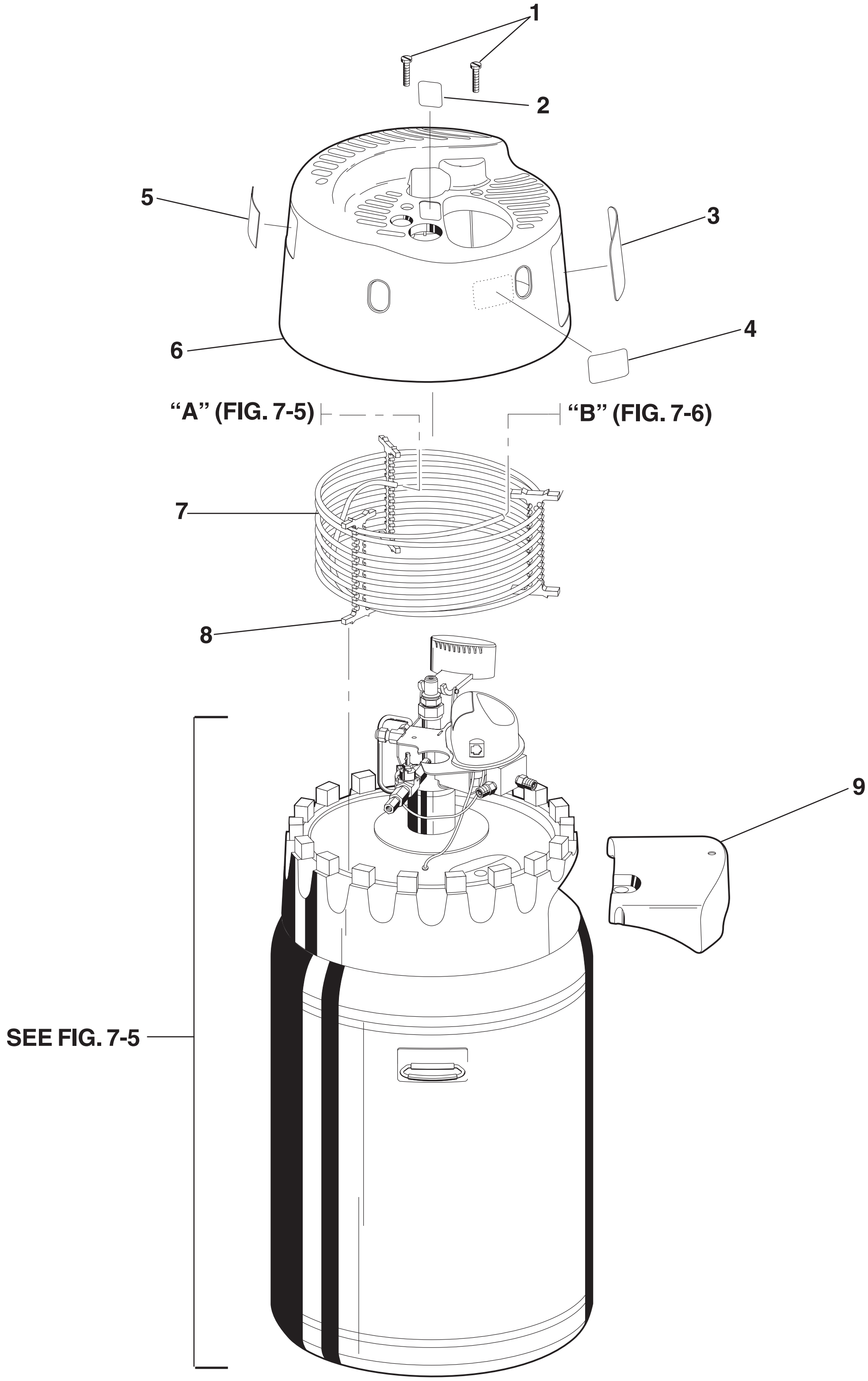


FIGURE 7-4
Universal Reservoir

FIGURE 7-5 PARTS LIST - HELiOS UNIVERSAL RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701635-00	Screw, Socket Head Cap – 10-24 x 3/8-in.	4
2	B-701695-00	Tube, Black Flexible – 1/16-in. x 12-in.	1
3	B-775794-00	Clamp, 1/16-in. Flexible Tubing	2
4	B-778167-00	Fitting, Brass - 1/16-in. Barb x 10-32	1
5	B-775139-00	Relief Valve, Secondary, Universal Res. (30 psig)	1
6	B-778157-00	Fitting, Brass – 1/8-in. Barb x 10-32	1
7	B-702105-00	Relief/Economizer Valve, Universal Res. (26/22 psig)	1
8	B-701630-01	Economizer Tube Assy. w/ Nuts and Ferrules	1
9	B-775265-00	Nut, Brass – ¼-in. Tube	1
10	B-775063-00	Ferrule, Brass – ¼-in. Tube	1
11	B-701622-00	Tee, LOX Withdrawal – 1/8 NPT x ¼-in. Tube x ¼-in. Tube	1
12	B-776175-00	Spring	1
13	B-702128-00	Compression Spacer	1
14	B-702127-00	O-ring, Silicone	2
15	Reference	Tube, Teflon Withdrawal – 30-in.	1
16	B-701543-00	Lower Shroud	1
17	B-701626-00	Umbrella Seal	1
18	B-701694-00	Tube, Red Flexible – 1/16-in. x 15-in.	1
19	Reference	Cryogenic Container	1
20	B-701699-00	Extension, Vent Valve	1
21	B-775133-00	Vent Valve Assembly – (includes items 22, 23, 24)	1
22	B-775241-00	Retaining Ring	1
23	B-775285-00	O-ring	1
24	B-775136-00	Spring Pin – 3/32-in. x ½-in. SS	1
25	B-775322-00	Fill Connector, Male – (includes items 26, 27)	1
26	B-775259-00	Cartridge Assembly w/Retainer Ring	1
27	B-775267-00	Retainer Ring	1

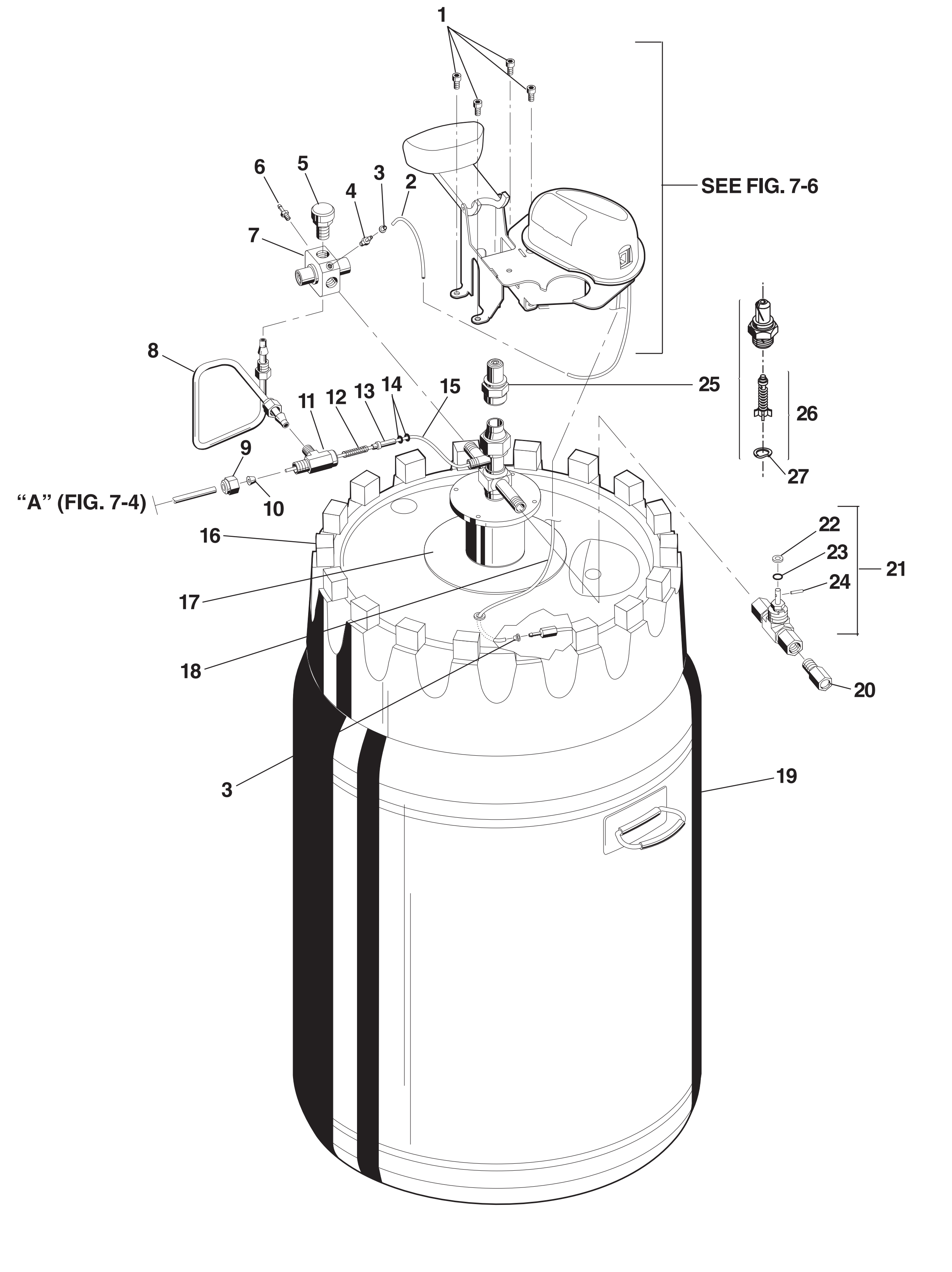


FIGURE 7-5
Universal Reservoir

FIGURE 7-6 PARTS LIST - HELiOS UNIVERSAL RESERVOIR			
Item	**Part Number**	**Description**	**Qty.**
1	B-701545-00	Release Button	1
2	B-702106-00	Release Lever, Universal Res.	1
3	B-701524-00	Screw, Torx Head, 8-16 x ¾-in.	2
4	B-777505-00	E-Ring	2
5	B-701634-00	Shaft, Pivot	1
6	B-701632-00	Bracket, Reservoir	1
7	B-702108-00	Mounting Block	1
8	B-702109-00	Screw, Mounting - FH	1
9	B-776997-00	DISS Fitting w/Poppet – 1/8 NPT x 9/16-18	1
10	B-701629-00	Connector, Flow Restrictor	1
11	B-775063-00	Ferrule, Brass – ¼-in. Tube	1
12	B-775265-00	Nut, Brass – ¼-in. Tube	1
13	B-701695-00	Tube, Black Flexible – 1/16-in. x 12-in.	1
14	B-701694-00	Tube, Red Flexible – 1/16-in. x 15-in.	1
15	B-494788-00	Contents Indicator Module –(includes items 16, 17)	1
16	B-492297-00	Battery, 9-Volt Alkaline	1
17	B-701523-00	Battery Door	1
18	B-701635-00	Screw, Socket Head Cap – 10-24 x 3/8-in.	4

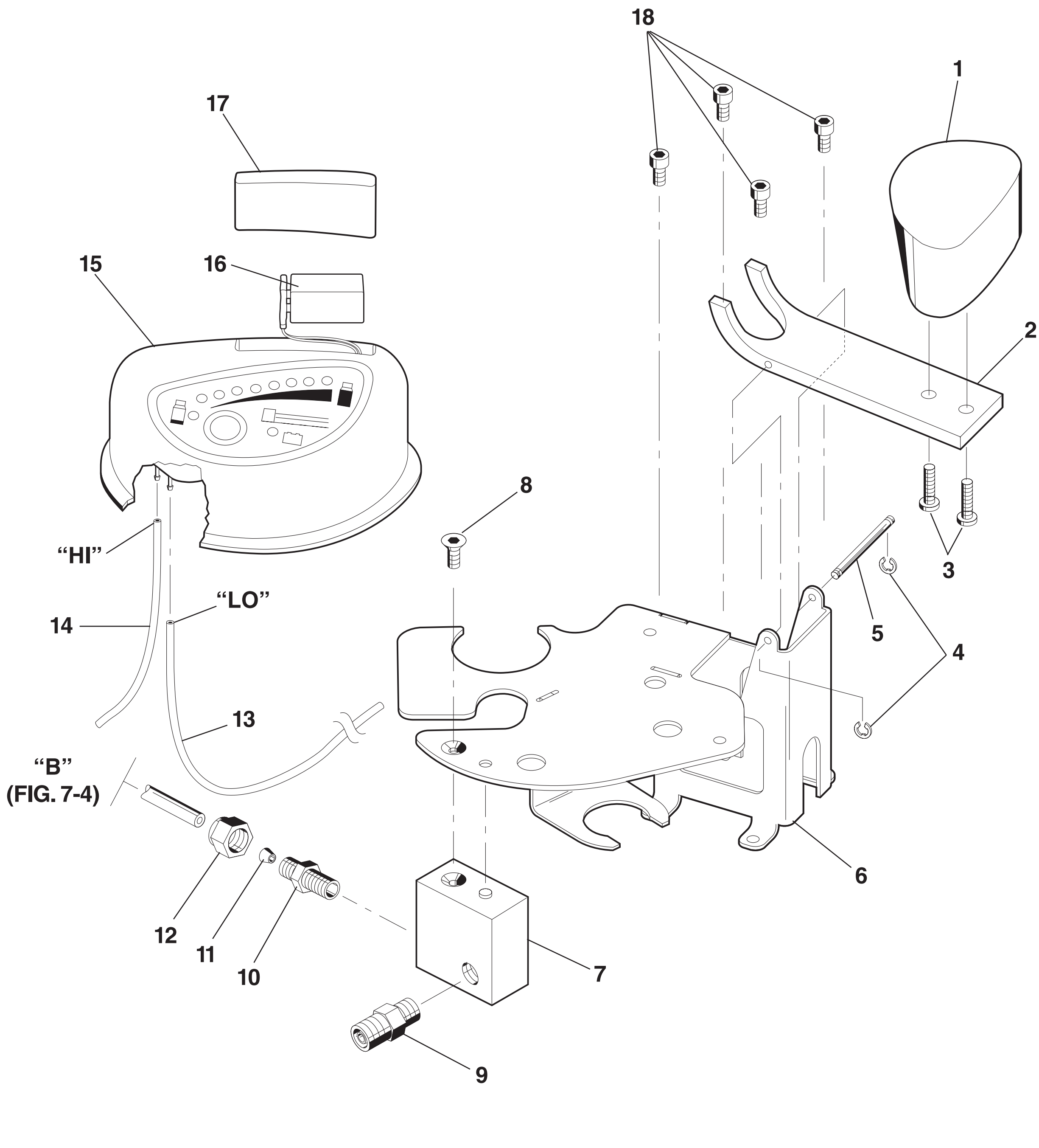


FIGURE 7-6
Universal Reservoir

Section 8

HELiOS 300 GENERAL INFORMATION

This section provides general information on the HELiOS 300 Portable liquid oxygen system (Figure 8-1). This information includes a product description; performance specifications; unpacking, installation, and repacking procedures; description of controls, indicators, and connectors; filling instructions; operating procedures; and maintenance.

Figure 8-1: HELiOS 300 Portable

8.1 PRODUCT DESCRIPTION

The HELiOS 300 Portable is an extremely small, lightweight portable liquid oxygen unit that can be used as a 24 hour per day interface for oxygen therapy patients. The H-300, when used with the HELiOS Reservoir, provides an integrated oxygen delivery system. When the patient fills the H-300 with liquid oxygen for ambulatory use, it provides about 10 hours of oxygen at a flow setting of 2 using an integral 4:1 conserving module. For sleep and sedentary periods at home, the patient attaches a flexible oxygen supply tube from the Reservoir to the H-300. This enables the patient to breathe gaseous oxygen and minimize normal evaporative losses from the Reservoir.

Since the H-300 is intended to be with the patient continuously, it is small, inconspicuous, and can be carried or positioned in various ways to accommodate a wide range of daily activities. The controls are large and clearly labeled. The flow knob makes a noticeable snapping sound between settings and has large, easy to read numbers. Flow settings below 1 provide continuous oxygen flow while settings of 1 and above provide demand flow at a 4:1 conserving ratio. The vent valve lever, located on the back of the H-300, faces the patient during a fill for easy opening and closing. The tubing connections for the dual lumen cannula are easy to use and are protected from breakage by not extending beyond the case.

For ambulatory use, the H-300 can be filled from the HELiOS Reservoir or from a Puritan-Bennett Companion Stationary. The H-300 typically fills in less than a minute and holds slightly less than one pound (.45 kg) of liquid oxygen. A full H-300 weighs 3.6 lbs. (1.6 kg). A simple mechanical display, based on the change in weight from full to empty, indicates liquid oxygen contents when the patient lifts the unit by a strap. The H-300, when filled with liquid oxygen, can be used in the normal upright position or in the warning label down position.

For a more technical description of how the H-300 operates, refer to Section 9, Theory of Operation.

8.2 PERFORMANCE SPECIFICATIONS

The HELiOS 300 performance specifications are listed below in Table 8-1.

TABLE 8-1

HELiOS 300 PORTABLE SPECIFICATIONS*	
Volume of Liquid Oxygen *Typical*	 0.38 liters/23 in³
Weight of Liquid Oxygen **At 22 psig (152 kPa)** **Saturation (typical)**	 0.9 lbs/.41 kg
Gaseous Oxygen Equivalent **(at 1 atm. and 70°F)**	 308 liters/10.9 ft³
Height	10.5 in./26.7 cm
Empty Weight	2.7 lbs/1.2 kg
Full Weight	3.6 lbs/1.6 kg
Economizer Pressure	22 psig/152 kPa Nominal (Acceptable Range 20.5-23.0 psig/141-159 kPa)
Primary Relief **Valve Pressure**	27 psig/186 kPa Nominal (Acceptable Range 24.0-30.0 psig/166-207 kPa)
Secondary Relief **Valve Pressure**	80 psig/552 kPa Nominal (Acceptable Range 75-85 psig/518-587 kPa)
Normal Evaporation Rate *Typical* *Maximum*	 1.0 lbs./0.45 kg per Day 1.5 lbs/0.68 kg per Day
Typical Fill Time *Warm Unit*	 ≅ 40 seconds
Flow Settings *Continuous Mode* *Demand Mode*	 .12, .25, .5, .75 1, 1.5, 2, 2.5, 3, 3.5, 4
Contents Indicator	Mechanical, spring-based weight scale
Environmental *Operating Temp.* *Storage Temp.*	 -20°C to 40°C 95% max. relative humidity -40°C to 70°C 90% max. relative humidity

* Specifications subject to change without notice.

8.3 UNPACKING, INSTALLATION, AND REPACKING

Perform the following procedures when unpacking, installing or repacking a HELiOS 300 unit.

8.3.1 Unpacking

1. Examine the shipping carton for damage. If the carton is damaged, or its contents are suspected of being damaged, photograph the damaged carton before the H-300 is unpacked. Contact the carrier to request a damage inspection. Contact the shipping point immediately.

2. Place the shipping carton on a flat surface with the shipping arrows pointing upwards.

3. Carefully lift the H-300 out of the carton and remove it from the plastic bag.

4. Compare the packing list attached to the carton's exterior with the shipment received. If any discrepancies exist, contact Puritan-Bennett immediately at 1-800-497-4968.

5. Thoroughly inspect the exterior of the H-300 for damage (dents, cracks, etc.).

6. Save all packing materials and the shipping carton for reuse.

8.3.2 Installation

Before installing the H-300 in a patient's home, read and understand Section 8.4, Controls, Indicators, and Connectors; Section 8.5, Filling Instructions; and Section 8.6, Operating Procedures. Perform the following steps upon receipt of shipment:

1. Record the H-300 serial number. The serial number is etched on the cryogenic container. You can view it through the contents indicator window on the back of the unit.

2. Verify the availability of dual lumen cannulas for use with the H-300.

3. Verify receipt of the HELiOS Operating Instructions.

8.3.3 Repacking for Return

To return a product, contact Puritan-Bennett at 1-800-255-6774 (press 2) and ask to speak with a Technical Support Representative. A Return Goods Authorization (RGA) number will be issued to track the product return. Please have available your account number, the **model and serial number of the product**, and the reason for returning the product when you call to request an RGA. Return the unit in its original carton, if possible. If the original carton is not available, you may purchase a new carton (Section 1.8, Accessories).

WARNING

Fire hazard and extreme cold hazard. Do not package or ship units that contain liquid or gaseous oxygen. Liquid oxygen spillage and high oxygen concentrations are possible. Empty oxygen contents completely before packaging or shipping units.

1. Obtain the proper carton and insert for the H-300 you wish to package (Section 1.8, Accessories).

2. Carefully place the carton insert around the H-300.

3. Fold down the carton top flaps and secure the carton with packing tape.

8.4 CONTROLS, INDICATORS, AND CONNECTORS

The controls, indicators, and connectors that are used on the H-300 unit are shown in Figure 8-2. Their functions are described below.

8.4.1 Fill Connector

The H-300 uses a Puritan-Bennett bottom fill connector to receive liquid oxygen from the Reservoir. It is the female half of a cryogenic quick connect coupling system. A spring loaded poppet automatically opens when the connector is engaged and automatically closes when the connector is disengaged.

8.4.2 Vent Valve

The vent valve is a lever-actuated, spring-loaded valve located in the back of the H-300. The patient pulls the lever down and holds it in the extended position to begin filling the H-300. When the H-300 is full, the patient moves the lever up to close the valve and terminate the filling process.

8.4.3 Contents Indicator

The contents indicator displays the amount of liquid oxygen in the H-300. It is a mechanical, spring-balanced indicator that is built into the rear cover of the H-300. When the patient lifts the H-300 by its strap, a green bar fills the indicator window a distance proportional to the amount of liquid oxygen in the unit.

8.4.4 Demand Flow Control

The demand flow control enables the patient to select one of eleven flow settings. The adjustable, rotary indexed control provides continuous oxygen flow at settings less than 1 and demand oxygen flow at settings from 1 to 4. The available settings are 0, .12, .25, .5, .75, 1, 1.5, 2, 2.5, 3, 3.5, 4.

8.4.5 Oxygen Supply Tube Quick Connect

The oxygen supply tube quick connect provides a means of connecting a flexible oxygen supply tube from the HELiOS Reservoir to the H-300. The patient inserts the oxygen supply tube connector into the H-300 quick connect until it snaps in place. To disconnect and remove the oxygen supply tube, the patient depresses the quick connect button.

8.4.6 Oxygen Outlet Connector

The oxygen outlet connector is one of a pair of barbed tubing connectors located on the front sidecover of the H-300. The patient attaches either tube of a dual-lumen cannula to this connector to receive oxygen flow from the unit.

8.4.7 Sense Connector

The sense connector is the barbed tubing connector located below the oxygen outlet connector on the front sidecover of the H-300. Either tube of a dual-lumen cannula attaches to this connector to enable the H-300 to sense patient inhalation and exhalation.

8.4.8 Dual-Lumen Cannula

The dual-lumen cannula is a special oxygen cannula with two connecting tubes for use with the H-300. One cannula tube attaches to the H-300 oxygen outlet connector and routes oxygen flow to the patient. The second tube attaches to the H-300 sense connector and routes the patient's inspiratory pressure signal to the unit. The cannula tubes are interchangeable on the connectors.

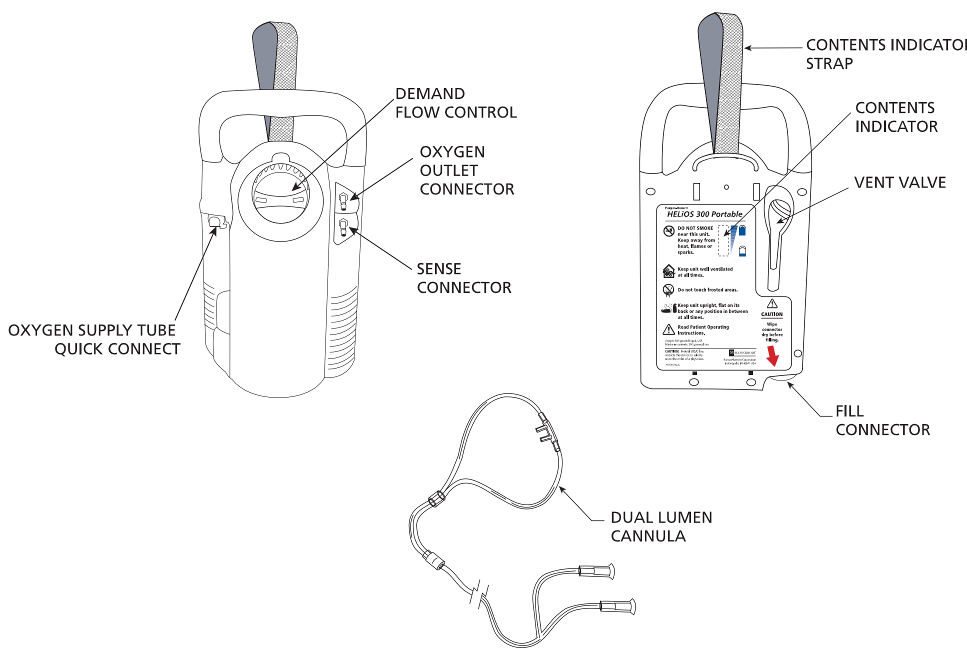


Figure 8-2: Controls, Indicators, and Connectors

8.5 FILLING INSTRUCTIONS

The H-300 can be filled with liquid oxygen from the HELiOS Reservoir or from a Puritan-Bennett Companion Stationary. The filling source liquid oxygen must be at 22 psig (152 kPa) saturation pressure or greater. The information in this section will help you fill the H-300 with liquid oxygen in a proper, safe, and efficient manner.

8.5.1 Pre-Fill Inspection

Perform the following procedure to visually inspect the H-300 and determine its operational status before filling. Correct observed problems before proceeding to fill the unit.

1. Visually inspect the H-300 unit for overall product integrity (for example, cracked or damaged components).
2. Verify that the warning label is present and legible on the unit (Figure 8-3).
3. Verify that the fill connector poppet is not worn, leaking, or damaged. Inspect the circular, white lip seal in the fill connector for cracks or signs of wear.
4. Move the vent valve lever down to the open position. Verify that the lever moves smoothly when opening and closing the valve.
5. Hold the H-300 on a table and carefully pull up on the contents indicator strap. Verify that the indicator mechanism moves smoothly.

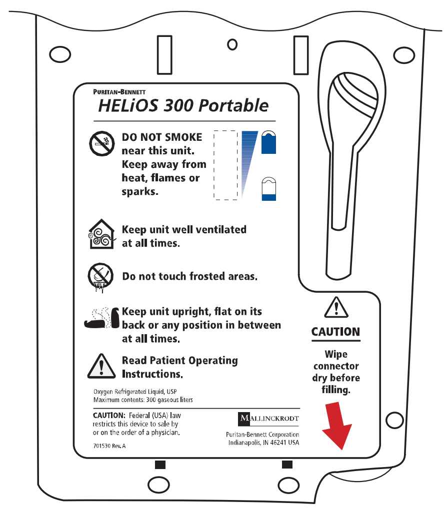


Figure 8-3: Portable Warning Label

8.5.2 Filling Procedure

Fill the H-300 with liquid oxygen from the Reservoir as follows:

1. Using a clean, dry, lint-free cloth, dry the male fill connector on the Reservoir and the female fill connector on the H-300.
2. Check the Reservoir contents indicator to make sure there is enough liquid oxygen for the filling operation.
3. Hold the H-300 with one hand and position the contoured case over the matching recessed area in the Reservoir cover (Figure 8-4).

Figure 8-4: Positioning the H-300 for Filling

WARNING

Extreme cold hazard. Do not depress or disturb the plastic poppet in the center of the Reservoir fill connector. This will cause an uncontrolled release of liquid oxygen from the fill connector.

4. Lower the H-300 carefully into place, ensuring the fill connectors are properly aligned.
5. Place one or both hands on top of the H-300 directly over the fill connector and press straight down. This will lower the unit approximately 3/8 in. (1 cm), properly engaging the fill connectors. Do not depress the release button when engaging the H-300.
6. While holding the H-300 in this position, move the vent valve lever to the open position, 90° down from the normal closed position (Figure 8-5). A hissing noise should be noticeable. During the filling operation, maintain a slight downward pressure on the H-300 with one hand to ensure stability and proper filling position.

WARNING

Extreme cold hazard. Do not leave the HELiOS Portable unattended during the filling operation. Excessive liquid oxygen discharge can occur.

Figure 8-5:Opening the Vent Valve

7. When you notice a change in the sound of the venting gas, followed by the emission of a dense, white vapor around the Reservoir shroud, close the vent valve. Fill times may vary according to the temperature of the H-300 container before filling and the Reservoir pressure. Typical fill time is approximately 40 seconds.

CAUTION: If the vent valve fails to close and the hissing continues, remove the H-300 by pressing the release button on the Reservoir (Figure 8-6). Keep the H-300 in an upright position. The H-300 will stop venting in a few minutes. Allow the unit to warm until you can close the vent valve. It may require as much as 60 minutes with the flow control off for the H-300 to restore adequate pressure for accurate oxygen delivery. An alternate source of oxygen, such as a flow control valve attached to the Reservoir, can be used if needed.

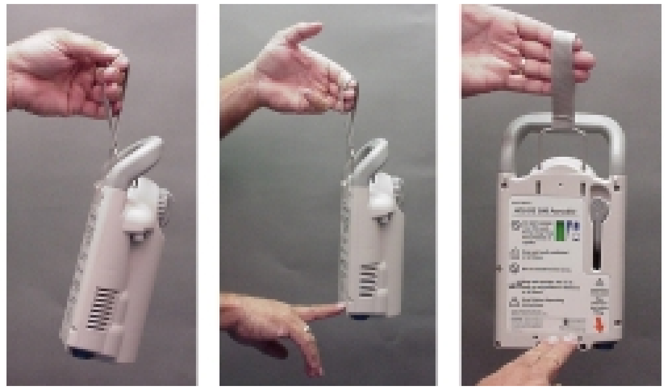
WARNING

Extreme cold hazard. Liquid oxygen discharge from the fill connector can occur. When disconnecting the H-300, never stand directly over the Reservoir fill connector. If the Reservoir fill connector stays open and minor liquid oxygen discharge occurs, carefully re-engage and disengage the H-300 to help dislodge any ice or other obstruction. If major liquid oxygen discharge (steady stream) occurs, open the reservoir vent valve (if safely possible) to vent pressure and stop the release of liquid oxygen. Open windows and doors to ventilate the room. Do not walk on areas exposed to liquid oxygen for 60 minutes after frost disappears.

8. Disengage the H-300 from the Reservoir by holding the H-300 handle and pressing the release button (Figure 8-6). Always hold the H-300 with one hand when attempting to disengage it. Should the units not disengage easily, they may be frozen together. **Do not use force.** Allow a few moments for the frozen parts to warm. Disengage the units after the ice has melted.

Figure 8-6: Disengaging the H-300

9. Check the oxygen contents indicator to make sure the H-300 is filled to the desired level. To operate the contents indicator: (1) lift the H-300 by the contents indicator strap, (2) push the bottom backside of the unit so that it is straight up and down, and (3) observe the green indicator bar that displays the liquid oxygen contents level inside the clear window (Figure 8-7). The green indicator should completely fill the window when the unit is full (3.4 lbs/1.5 kg total weight).



(1) (2) (3)

Figure 8-7:Checking the Liquid Oxygen Level

8.5.3 Post-Fill Inspection

Perform the following procedure to inspect the H-300 and determine its operational status after filling it with liquid oxygen. Correct observed problems before placing the unit in service.

1. Verify that the H-300 fill connector poppet is closed and not leaking.

2. Verify that the vent valve is completely closed and not leaking.

3. Verify that the patient with a prescription from 1 to 4 receives a brief “puff” of oxygen at the beginning of inspiration and a continuous “tailflow” during the remainder of inspiration. There should be no flow during exhalation.

4. Verify that the patient with a prescription less than 1 receives continuous flow.

8.6 OPERATING PROCEDURES

The patient uses the H-300 in two different ways. First, the patient can fill the H-300 with liquid oxygen from the Reservoir for ambulatory use. The liquid oxygen vaporizes into gas in the H-300 and flows to the patient at the prescribed setting on the flow control. Second, the patient can connect a flexible oxygen supply tube from the Reservoir to the H-300 for sleep and sedentary use in the home. Gaseous oxygen from the Reservoir pressurizes the H-300 and flows to the patient at the prescribed setting on the flow control.

To operate an H-300 filled with liquid oxygen, perform the following steps:

1. Verify that there is adequate liquid oxygen in the H-300 to meet patient breathing needs.

2. Securely attach one of the tubes from the dual-lumen oxygen cannula to the H-300 oxygen outlet connector (upper connector). Securely attach the other cannula tube to the sense connector (lower connector). Adjust the cannula on the face to receive oxygen comfortably (Figure 8-8).

WARNING

Incorrect oxygen delivery hazard. Do not use the H-300 with a single-lumen cannula or a cannula longer than 7 feet (2.1 m).

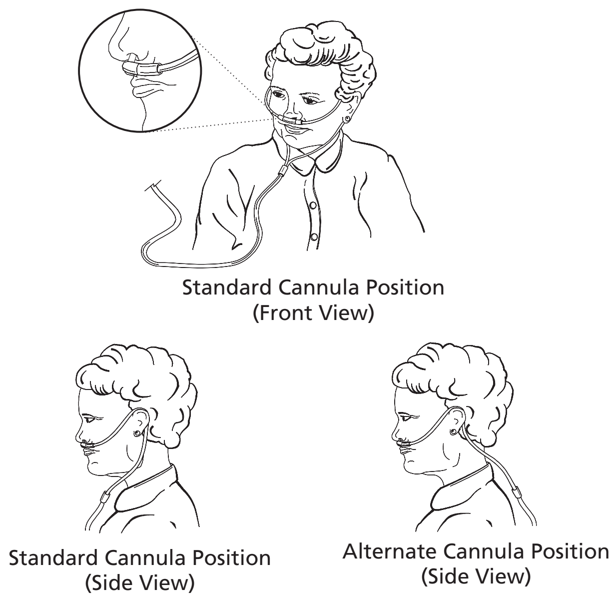


Figure 8-8: Adjusting the Dual-Lumen Cannula on Face

3. Turn the flow control knob to the prescribed setting.
4. Carry the H-300 by its permanent handle or use the optional belt pack.

WARNING

Fire hazard. Concentrated oxygen increases the risk of fire. Do not carry the H-300 under clothing. This unit normally vents oxygen. Wearing an H-300 under clothing may saturate fabrics with oxygen and cause them to burn rapidly if exposed to sparks or flame. It may take several hours for oxygen levels in fabrics to return to normal.

To operate an H-300 with gaseous oxygen supplied from the Reservoir oxygen outlet, perform the following steps:

1. Insert the flexible oxygen supply tube connector into the quick connect on the front of the H-300 and snap it in place.
2. Locate the oxygen DISS nut and tailpiece assembly attached to the opposite end of the flexible oxygen supply tube. Thread the nut and tailpiece assembly onto the Reservoir oxygen outlet connector until secure.

NOTE: This opens a poppet valve in the outlet connector and enables oxygen flow to the H-300.

WARNING

Incorrect gas delivery hazard. Use only the recommended flexible oxygen supply tube and oxygen gas source. Connecting the H-300 to an incorrect gas source can cause inhalation of hazardous substances.

CAUTION: Incorrect source pressure hazard. Connect the H-300 flexible oxygen supply tube to a HELiOS Reservoir or to another gaseous oxygen source that operates at pressures between 20.5 and 23.5 psig (141 and 162 kPa). Oxygen source pressures exceeding H-300 specifications can damage the H-300.

3. Securely attach one of the tubes from the dual-lumen oxygen cannula to the H-300 oxygen outlet connector (upper connector). Securely attach the other cannula tube to the sense connector (lower connector). Adjust the cannula on the face to receive oxygen comfortably (Figure 8-8).

WARNING

Incorrect oxygen delivery hazard. Do not use the Portable with a single-lumen cannula or a cannula longer than 7 feet (2.1 m).

4. Turn the flow control knob to the prescribed setting.
5. Carry the H-300 by its permanent handle or use the optional belt pack.

At flow control knob settings from 1 to 4, oxygen flows only when the H-300 senses the patient's inspiration. An initial "puff" of oxygen may be noticed, followed by a proportional flow of oxygen during the remainder of the inspiration. Oxygen flow stops during the exhalation phase of the breathing cycle. At flow control knob settings less than 1, oxygen flows continuously at the set rate during the entire breathing cycle.

8.7 MAINTENANCE

The H-300 Pre-Fill Inspection, Filling, and Post-Fill Inspection procedures should be performed every time the patient's Reservoir is filled. This provides routine assessment of the functional status of the H-300. Functional problems observed during these procedures must be corrected before placing the unit in service.

Use the information in Table 8-2 as a guide to clean, inspect, and test the H-300 Portable when functional problems are observed or as needed.

TABLE 8-2

H-300 MAINTENANCE GUIDE	
ITEM	**ACTION**
Cleaning	❑ Remove the covers and clean the interior and exterior of each cover with a mild detergent and water. Wipe dry with a towel. Use cotton swabs in tight places. Use Scotch-Brite abrasive pad with detergent to *lightly* buff out scuffmarks. ❑ Clean the H-300 plumbing with detergent and water. Dry with a towel and oil-free compressed gas. ⚠ **CAUTION: Do not allow liquids to enter the vent ports on the sides of the demand flow control valve and the R/E valve. Valve malfunction can occur.** **NOTE:** Make sure that the fill connector and the vent valve shaft are thoroughly dry before proceeding.
Inspection	❑ Inspect the covers, flow knob, and vent valve lever for cracks, warpage, and discoloration. ❑ Verify that the warning label (Figure 8-3) is present and legible. ❑ Verify that the fill connector poppet is not worn or broken and that the lip seal is not cracked. ❑ Move the vent valve lever down to the open position. Verify the lever moves smoothly when opening and closing the valve. ❑ Carefully pull up on the contents indicator strap. Verify the indicator mechanism moves smoothly. ❑ Verify that the aluminum tubing is not bent or kinked and that the coils are uniform in appearance. ❑ Verify that the flexible tubing is not cut, pinched, or kinked.
Testing	❑ Perform Leak Test (Section 10.2). ❑ Perform Gaseous Oxygen Functional Tests (Section 10.3). ❑ Perform Liquid Oxygen Functional Tests (Section 10.4).

NOTE: The following cleaning and disinfecting solutions are acceptable for use with the HELiOS Reservoir:

Cleaning	• Sporicidin Disinfectant Solution • Mild dish washing detergent/warm water solution
Disinfecting	• Sporicidin Disinfectant Solution • Household Bleach (1:10 dilution with water, freshly made within 24 hours)

Section 9

HELiOS 300 THEORY OF OPERATION

This section describes the theory of operation for the HELiOS 300 Portable liquid oxygen system. Information presented in this section will help you understand how the HELiOS 300 system works. Items covered include functional descriptions of HELiOS 300 components and complete HELiOS 300 system operation.

NOTE: Numerical values used in this section are nominal values.

9.1 H-300 PORTABLE COMPONENTS

Following is a brief description of each of the major functional components of the HELiOS 300 unit.

9.1.1 Cryogenic Container

The H-300 holds about 0.9 pounds (0.41 kg) of liquid oxygen when filled from the HELiOS Reservoir. Liquid oxygen stored in the H-300 is typically saturated and boiling at a temperature of about -277°F (-172°C). The constant transfer of heat from the atmosphere into the system keeps the liquid oxygen boiling and vaporizing into gas. If the heat flow into the liquid oxygen is not controlled, vaporization occurs too rapidly, and excess oxygen is vented to the atmosphere and wasted. The cryogenic container (Figure 9-1) is designed to minimize the transfer of heat from the atmosphere to the liquid oxygen contents. This is done by slowing down the three ways that heat can transfer: conduction, convection, and radiation.

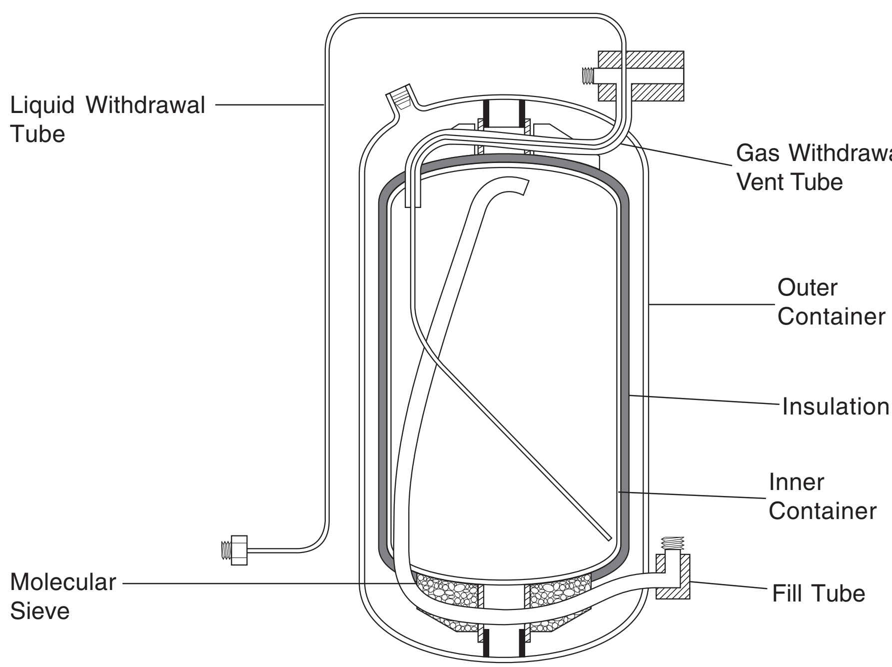


Figure 9-1: H-300 Cryogenic Container

Conduction is the transfer of heat through a material, such as metal, by collisions of molecules in the material. Molecules at the hotter end of the material are moving faster than molecules at the cooler end. Heat is transferred from molecule to molecule as fast moving molecules run into the slower moving ones. Conductive heat transfer is kept to a minimum by placing the liquid oxygen in a stainless steel inner container suspended within a stainless steel outer container. This reduces the number of places where the warmer outer container comes into physical contact with the colder inner container that holds the liquid oxygen.

Convection is the transfer of heat by motion of a heated fluid (gas or liquid) from one place to another. When a layer of gas, for example, is heated, it tends to rise above or move away from the surrounding gas. Cooler gas moves in to take its place. This gas is heated, rises and moves away. Heat is transferred by circulation of the heated gas. To minimize convective heat transfer between the warm outer container and cold inner container, air is removed from the sealed space between the outer and inner containers. A vacuum applied through the evacuation port removes most of the gas molecules in this space. Since no vacuum created on earth is perfect, a molecular sieve material is placed in the vacuum space against the inner container. When liquid oxygen in the inner container cools the molecular sieve to cryogenic temperatures, remaining gas molecules are removed from the vacuum space by adsorption into the sieve. This substantially improves the vacuum and reduces heat transfer by convection.

Radiation is the transfer of energy at the speed of light in the electromagnetic spectrum. Warm bodies emit infrared radiation, a form of light. Like visible light, mirrors and shiny surfaces reflect infrared. When infrared is absorbed, it creates a rise in temperature of the absorbing material. To minimize energy transfer by radiation, the H-300 inner container is wrapped with multiple, alternating layers of aluminum foil and fiberglass paper. This insulation wrap reflects back radiant energy from the outer container and reduces radiant energy absorption by the liquid oxygen.

The unique design of the H-300 cryogenic container also increases safety in the event the H-300 is tipped over or laid on its back. A typical cryogenic container leaks liquid oxygen to atmosphere through the gas withdrawal circuit if the container is not kept upright. If the H-300 is laid over on its back or other acceptable position, the unique location of the container gas withdrawal tube prevents discharge of liquid oxygen.

9.1.2 Fill Connector/Quick Connect

The fill connector/quick connect (Figure 9-2) on the H-300 is the female half of a fluid coupling system. It mates with the male fill connector on a HELiOS Reservoir. The H-300 fill connector allows liquid oxygen to transfer from the Reservoir unit into the H-300. Within the female fill connector is a cartridge assembly made up of a spring and a poppet. When the fill connector disengages, the spring holds the poppet closed and maintains a leak-tight seal. When the female fill connector engages the male fill connector, both connector poppets move back off of their respective seats (Figure 9-3). This creates an open path for liquid oxygen to transfer through the connection. A lip seal in the female fill connector assembly prevents leakage between the female and male fill connectors during liquid oxygen transfer.

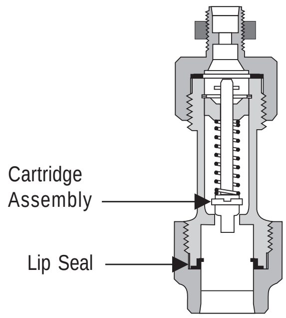


Figure 9-2: Female Fill Connector

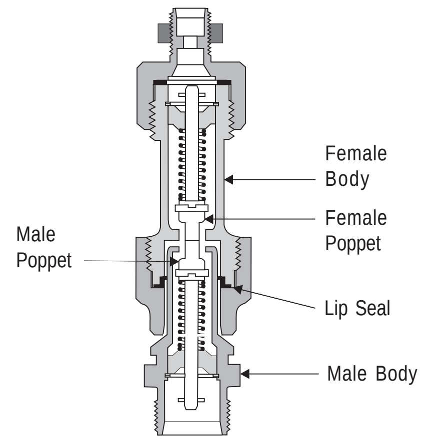


Figure 9-3: Male/Female Fill Connectors Fully Engaged

9.1.3 Vent Valve

The vent valve (Figure 9-4) is a lever-actuated, spring-loaded poppet valve that vents the inner container to atmosphere. Venting of the inner container is required to fill the H-300 with liquid oxygen. Pulling the valve lever out 90° to the H-300 cover moves the spring-loaded poppet off of its seat. This opens the valve to allow gas to vent through the vent extension tube and out the bottom of the H-300.

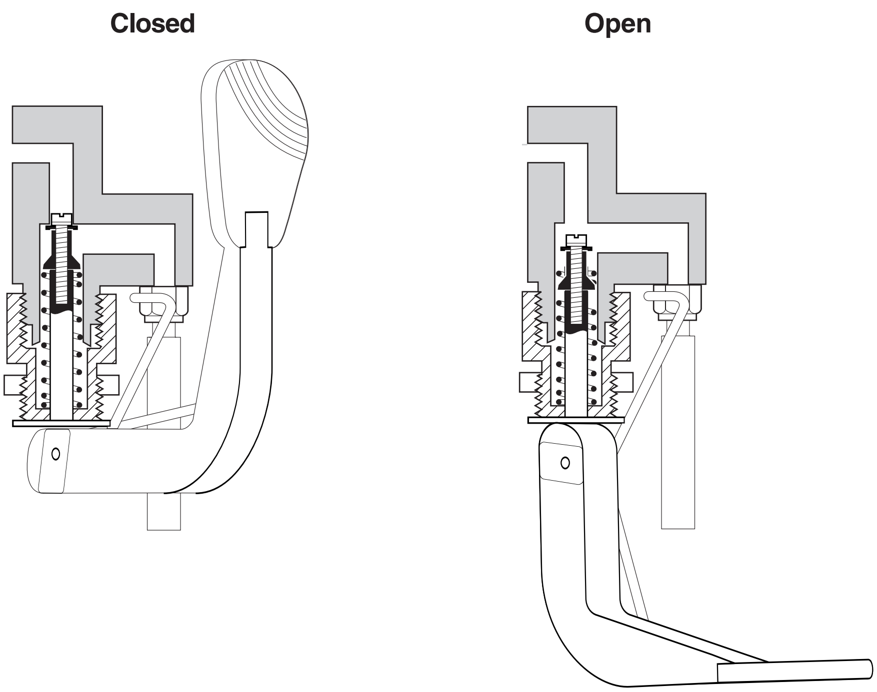


Figure 9-4: Vent Valve

9.1.4 Relief/Economizer Valve

The relief/economizer valve is a pressure-regulating device that combines the function of a primary relief valve and an economizer valve into one component (Figure 9-5).

The primary relief valve establishes the system pressure of the H-300 when there *is no* oxygen flow through the oxygen outlet (“Standby” condition). It contains a spring-loaded diaphragm that, in its normal state, seals a port that is vented to atmosphere. System pressure acts on one side of the diaphragm. When this pressure overcomes the force created by the spring and atmospheric pressure acting on the opposite side, the diaphragm lifts off of the port. This allows gas in the space above the liquid oxygen (headspace) to vent to atmosphere. The venting gas lowers the system pressure until equilibrium is established between the opening and closing forces on the diaphragm. The rate at which gas is vented out the primary relief valve is determined by the normal evaporation rate (NER) of the system. The H-300 maintains a primary relief valve nominal pressure of 27 psig (186 kPa) when in the Standby condition.

The economizer valve establishes the system pressure of the H-300 when there *is* oxygen flow through the oxygen outlet (“Oxygen Flow” condition). It allows a patient to first breathe gaseous oxygen from the headspace in the H-300. This headspace gas accumulates and builds pressure due to the constant boiling of the liquid oxygen at the normal evaporation rate (NER). Oxygen is conserved by allowing the patient to withdraw and use this gas rather than letting it build pressure and eventually vent away through the primary relief valve. The economizer valve contains a spring-loaded diaphragm that, in its normal state, seals a port that is connected to the H-300 oxygen outlet circuit. When system pressure exceeds 22 psig (152 kPa), the economizer diaphragm lifts off of its port. This opens a flow path from the gaseous headspace, through the economizer warming coil, to the oxygen outlet. Under no-flow conditions, the headspace gas will approach and eventually arrive at primary relief valve pressure, 27 psig (186 kPa). When flow through the oxygen outlet is established, gas moves from the headspace through the open economizer valve. When this flow is greater than the NER of the system (about 0.3 L/min), headspace pressure begins to decrease. The pressure will eventually decrease to a point where the opening force on the diaphragm created by the pressure and the closing force created by the spring come to equilibrium. This equilibrium is maintained at 22 psig (152 kPa) because the economizer valve stays open just enough to allow the small NER flow to pass through. When the NER gas is removed from the headspace at the same rate that it enters, a constant system pressure of 22 psig (152 kPa) is maintained. If the outlet flow demand exceeds the NER flow (about 0.3 L/min) when at economizer pressure, liquid oxygen is withdrawn and vaporized in the liquid withdrawal warming coil. This flow, together with the small NER flow through the economizer valve, satisfies the flow demand on the system. When the flow demand at the oxygen outlet stops, the NER causes pressure to build back toward the primary relief valve set point.

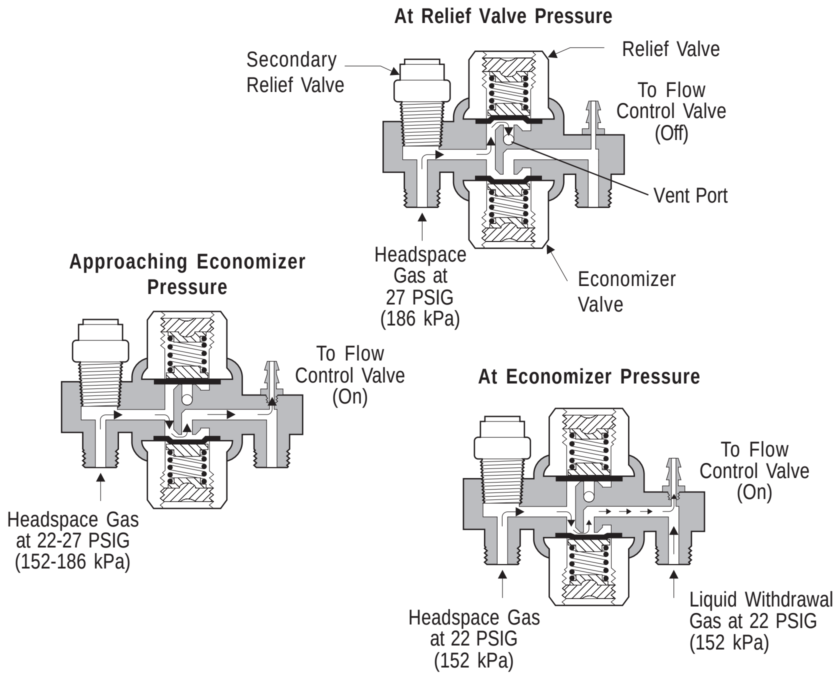


Figure 9-5: Relief/Economizer Valve

9.1.5 Secondary Relief Valve

The secondary relief valve in the H-300 is used as a safety backup in the event that the primary relief valve fails to limit system pressure to an acceptable range. It is mounted on the relief/economizer valve body. The secondary relief valve consists of a poppet with an elastomer seal and a spring (Figure 9-6). In its normal state, the poppet seals a port that vents to atmosphere. When system pressure acting on one side of the poppet overcomes the force created by the spring and atmospheric pressure, the poppet lifts off its seat and allows headspace gas to vent to atmosphere. The venting gas lowers the system pressure until equilibrium is established between the opening and closing forces on the poppet. If system pressure increases further, the relief valve poppet opens a greater amount and vents additional gas to maintain the force equilibrium on the poppet. The secondary relief valve has a nominal pressure setting of 80 psig (552 kPa).

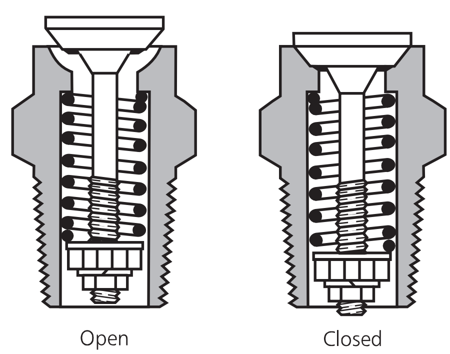


Figure 9-6: Secondary Relief Valve

9.1.6 Warming Coils

There are two warming coils used on the H-300. Each warming coil is a heat exchanger that transfers heat from the surrounding atmosphere to the fluid contents inside the coil (Figure 9-7). The liquid withdrawal warming coil is a loosely wound coil of 1/8 in. aluminum tubing about 4.5 feet (1.4 meters) long. It connects the container liquid withdrawal tube to the relief/economizer valve outlet tee. The gas withdrawal warming coil is a more tightly wound coil of 1/8 in. aluminum tubing about 3.5 feet (1.1 meters) long. It connects the container gas outlet port with the relief/economizer valve inlet tee. Oxygen flows through the warming coils only when there is a flow demand at the oxygen outlet. The gas withdrawal warming coil warms the cold gaseous oxygen from the headspace that flows through the economizer valve. The patient breathes this gas while the H-300 pressure is at or above the economizer setting (22 psig/152 kPa). The liquid withdrawal warming coil vaporizes liquid oxygen that is discharged from the H-300 liquid withdrawal tube. This occurs once system pressure stabilizes at the economizer setting and the ongoing patient flow demand exceeds flow through the economizer valve.

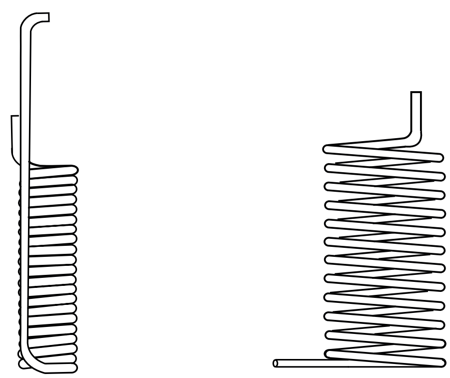


Figure 9-7: Warming Coils

9.1.7 Demand Flow Control Valve

The H-300 demand flow control valve is an oxygen conserving device. It provides demand dose oxygen to the patient upon each inspiration at flow settings from 1 to 4. Continuous oxygen flow occurs at flow settings less than 1. In the demand mode, patients achieve equivalent oxygenation while using only about 25% of the prescribed continuous oxygen flow rate. The demand flow control valve consists of a rotary, fixed orifice flow control valve attached to a pneumatic demand valve (Figure 9-8). A dual lumen cannula provides the patient interface. One lumen and corresponding nasal prongs connects to the oxygen outlet port of the demand flow control valve. This connection provides oxygen flow to the patient. The second lumen and corresponding nasal prongs connects to the sense port of the demand flow control valve. This connection provides a pressure signal path that enables the demand valve to sense pressure changes as the patient inhales and exhales.

The 12 position flow control valve has a moveable rotor with eleven orifices of different sizes and an off position. Available flow settings range from .12 to 4 . Selection of a specific flow setting from 1 to 4 determines the volume of the initial bolus (puff) of oxygen delivered at the beginning of inspiration and the subsequent tail flow following the bolus. The tail flow continues until the end of the inspiration. Both the bolus volume and tail flow vary with the different flow control valve settings. For example, at the 2 setting, the volume of the bolus at the beginning of inspiration is 12 ml. The tail flow is 0.75 L/min until

inspiration ends. At the 4 setting, the volume of the bolus is 15 ml while the tail flow is 2 L/min. The flow control valve stores the metered oxygen until the demand valve senses the beginning of a patient inspiration.

When the patient inhales, a sub-atmospheric (negative) pressure inspiratory signal travels through one tube of the dual lumen cannula to the sense port. This sub-atmospheric pressure acts on the bottom of the sensor diaphragm. Atmospheric pressure acting on the top of the sensor diaphragm pushes the diaphragm off of a bleed port for the slave valve. This in turn bleeds pressure from the area below the slave diaphragm. A spring pushes the slave diaphragm down and opens the demand flow port. This releases the stored volume of oxygen in the flow control valve precharge chambers to the patient. The patient senses this initial flow as a “puff” of oxygen. The metered tail flow of oxygen immediately follows the puff and continues as long as the patient inhales. When the patient exhales, a positive pressure exhalation signal acts on the bottom of the sensor diaphragm. This pushes the sensor diaphragm up and blocks the slave valve bleed port. The resulting build up of pressure below the slave diaphragm overcomes the opposing slave spring force and pushes the diaphragm against the demand flow port. This closes the demand valve and stops oxygen flow to the patient.

At flow settings less than 1, the orifice plate blocks the gas supply to the chamber under the slave diaphragm. The patient’s first breath vents any residual pressure that may be present under the diaphragm. The slave diaphragm spring pushes the diaphragm off of the demand flow port. This allows the patient to receive continuous flow at the selected rate.

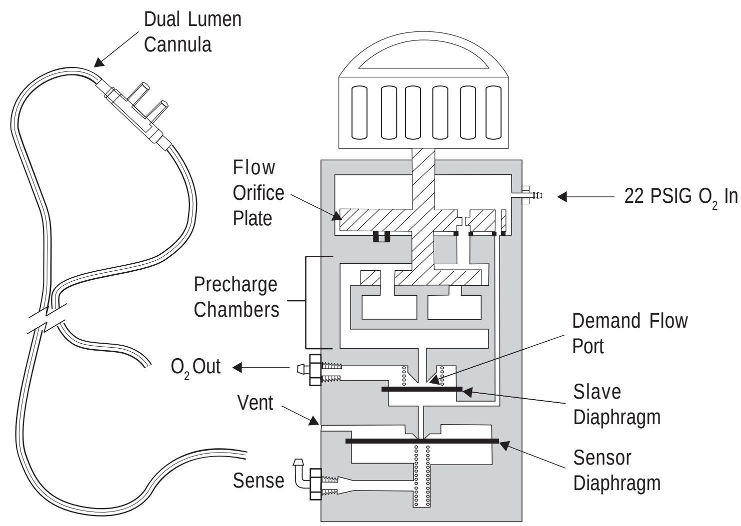


Figure 9-8: Demand Flow Control Valve

9.1.8 Oxygen Supply Tube Quick Connect and Inline Check Valve

The oxygen supply tube quick connect is a fluid coupling that enables the patient to connect the H-300 to a flexible oxygen supply tube from the DISS oxygen gas outlet of a HELiOS Reservoir. The patient can then breathe gaseous oxygen from the Reservoir through the H-300. The patient connects the oxygen supply tube by inserting the male nipple on one end of the tube into the quick connect until it snaps in place. A spring loaded latch holds the nipple in place. An O-ring on the nipple creates a leak tight seal. To disconnect, the patient depresses the latch button and removes the tubing nipple (Figure 9-9).

The inline check valve allows flow in one direction only through the oxygen supply tube quick connect. Oxygen from the Reservoir flows through the inline check valve and into the H-300 Portable. The check valve prevents gaseous oxygen in the H-300 from escaping through the quick connect when the oxygen supply tube is not used. It also prevents loss of H-300 pressure in the event that the oxygen supply tube from the Reservoir is cut. Movement of a flexible umbrella flap in the check valve allows flow in the forward direction but not in the reverse direction. An arrow on the check valve body indicates flow direction (Figure 9-10).

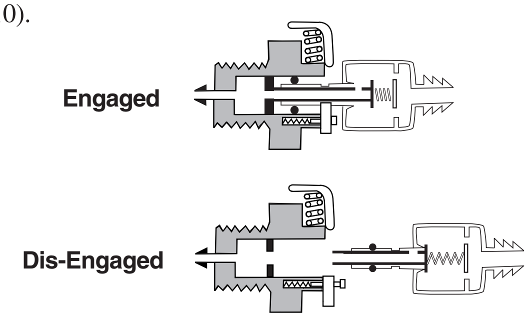


Figure 9-9: Oxygen Supply Tube Quick Connect

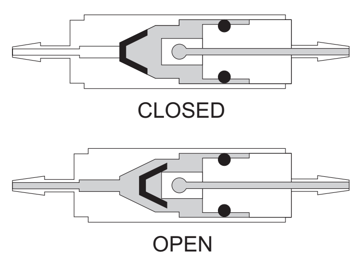


Figure 9-10: Inline Check Valve

9.1.9 Contents Indicator

The H-300 contents indicator is a mechanical, spring-balanced indicator that is built into the rear cover of the H-300 (Figure 9-11). The weight of the H-300 determines the relative position of the contents indicator. The patient suspends the H-300 from the contents indicator strap to take a reading. As the patient uses liquid oxygen and the weight of the H-300 changes, the position of the indicator changes proportionally.

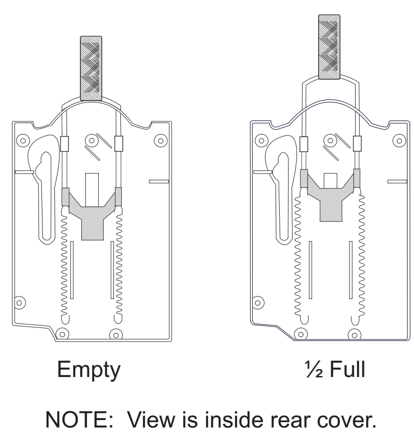


Figure 9-11: H-300 Contents Indicator

9.2 H-300 PORTABLE OPERATION

The H-300 provides a uniform patient interface for breathing oxygen either in the comfort of home or while being active away from home. The patient fills the H-300 with liquid oxygen from the Reservoir to satisfy ambulatory oxygen needs. During periods of sleep or other sedentary activities at home, the H-300 provides the patient with gaseous oxygen from the Reservoir by means of a flexible oxygen supply tube. The following summary provides a brief description of H-300 system operation while filling the unit, at fill termination, during no use standby, and during gaseous oxygen withdrawal.

9.2.1 Filling the Portable

The patient fills the H-300 with liquid oxygen from the HELiOS Reservoir. The H-300 is also compatible with the Puritan-Bennett Companion Stationary systems. The fill sequence begins by engaging the H-300 fill connector to the Reservoir fill connector. The patient then opens the H-300 vent valve to permit gas within the unit to escape to atmosphere (Figure 9-12). This creates the pressure drop necessary for the liquid oxygen to flow from the Reservoir into the H-300. At first, the liquid oxygen that leaves the Reservoir vaporizes into gas in the H-300 and vents to atmosphere through the vent valve. This “flash off” is due to the relatively warm temperature of the H-300 container and to the supersaturated condition created by the pressure drop during filling. Within a short time, the vaporization process cools the H-300 inner container to a temperature that enables liquid oxygen to be retained in the container.

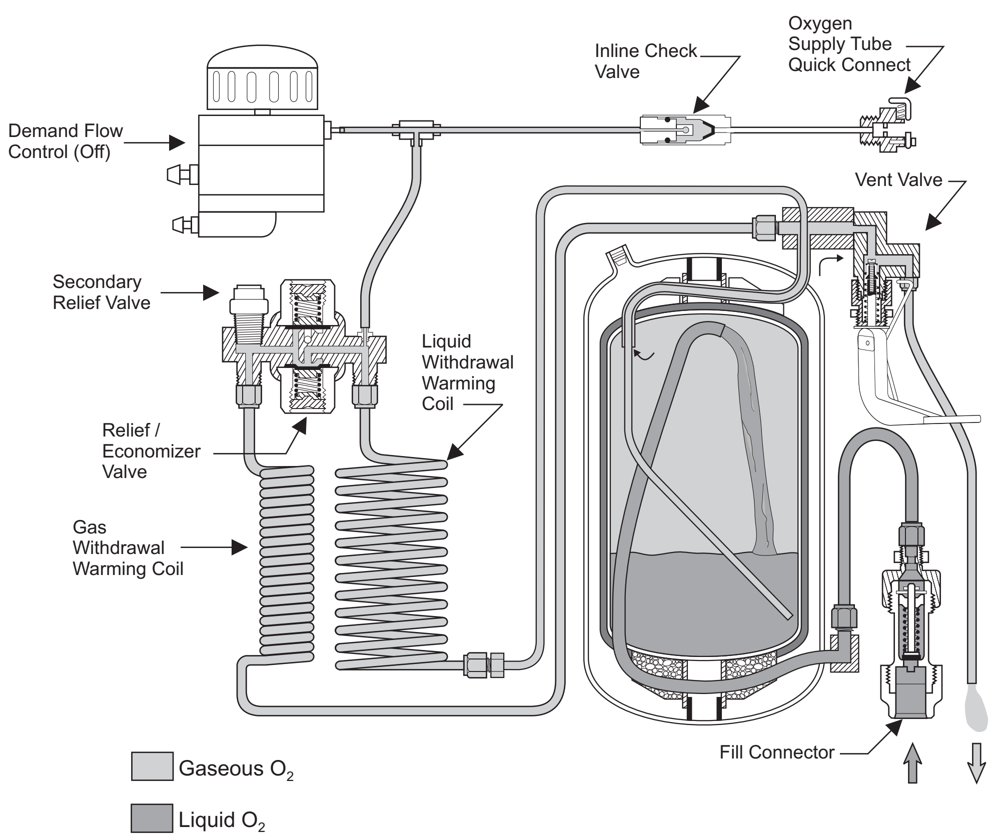


Figure 9-12: Filling the Portable

9.2.2 Fill Termination

When the liquid oxygen level in the inner container reaches the end of the gas withdrawal/ vent tube (Figure 9-13), liquid oxygen is expelled through the vent circuit to atmosphere. The venting sound changes and the liquid oxygen creates a dense vapor cloud as it discharges under the Reservoir shroud. When this occurs, the patient terminates the filling operation by closing the vent valve and disengaging the H-300 from the Reservoir. A mechanical release mechanism on the Reservoir helps disengage the frosted fill connectors.

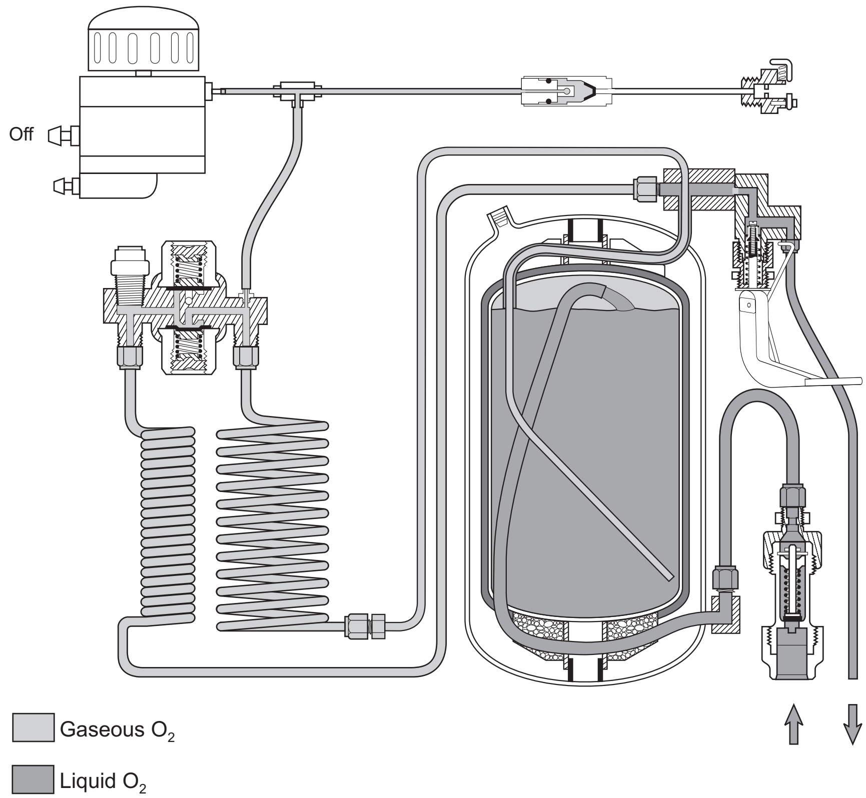


Figure 9-13: Fill Termination

9.2.3 Standby

When the H-300 contains liquid oxygen, and there is no oxygen flow demand on the system, the pressure in the system increases and eventually stabilizes at the primary relief valve set point, approximately 27 psig (186 kPa). The pressure increases due to the Normal Evaporation Rate (NER) of the system. The NER is a function of the constant rate at which ambient heat “leaks” into the liquid oxygen and causes it to boil when saturated. This constant boiling vaporizes some of the liquid oxygen into gas. Pressure increases in the container over time until it reaches the primary relief valve opening point. The primary relief valve maintains pressure equilibrium in the system by allowing gas in the container space above the liquid (headspace) to vent at the same rate that it is created by the NER (Figure 9-14). The vented gas represents the system’s NER loss. Due to the efficient design of the container, NER losses are kept to a minimum.

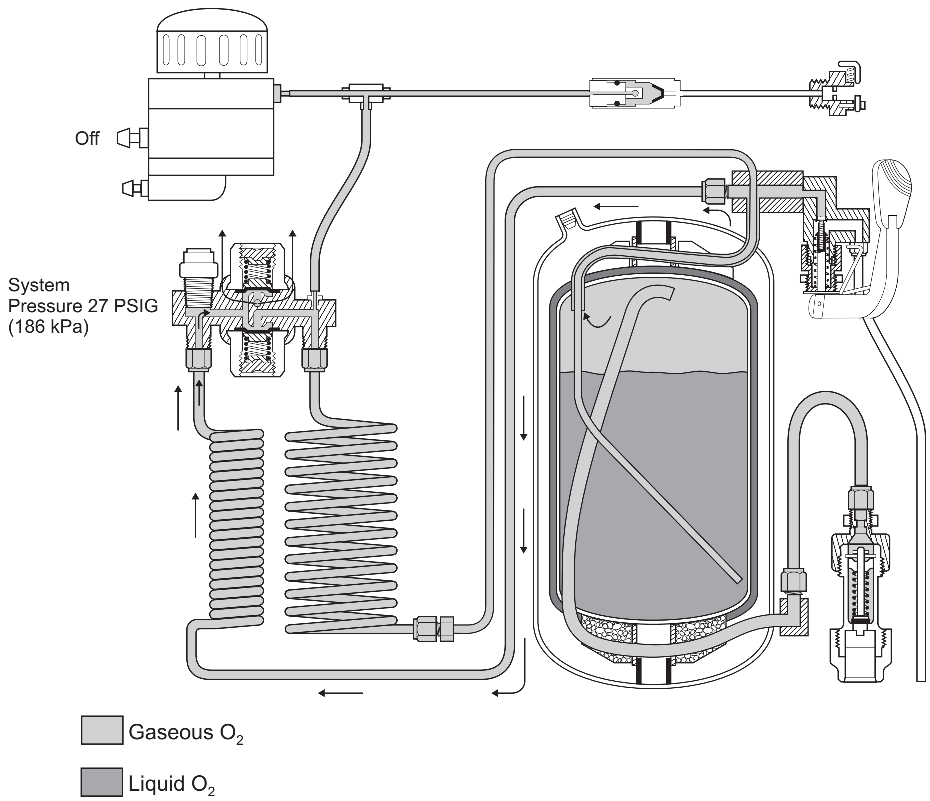


Figure 9-14: Standby

9.2.4 Gaseous Oxygen Use — H-300 Filled with Liquid Oxygen

When the patient breathes from an H-300 that contains liquid oxygen, the oxygen flow can come from two locations within the H-300: the headspace above the liquid oxygen or the liquid withdrawal tube. If the pressure inside the H-300 is between 22 psig and 27 psig (152 kPa and 186 kPa), the economizer valve opens. A flow demand at the oxygen outlet moves gas out of the demand flow control valve and creates a pressure drop at the outlet of the relief/economizer valve. As a result, container headspace pressure drives gaseous oxygen from the headspace, through the gas withdrawal warming coil, and through the open economizer valve to meet the demand at the oxygen outlet (Figure 9-15). Liquid oxygen does not move up through the liquid withdrawal tube because the gas pressure above the liquid in the tube remains the same as the headspace pressure above the liquid in the container. When the oxygen outlet flow demand is greater than the NER of the system, gas leaves the headspace faster than it is created by the NER. The pressure in the headspace begins to decrease. If the flow demand continues, the pressure in the headspace will eventually reach the set point of the economizer valve, 22 psig (152 kPa).

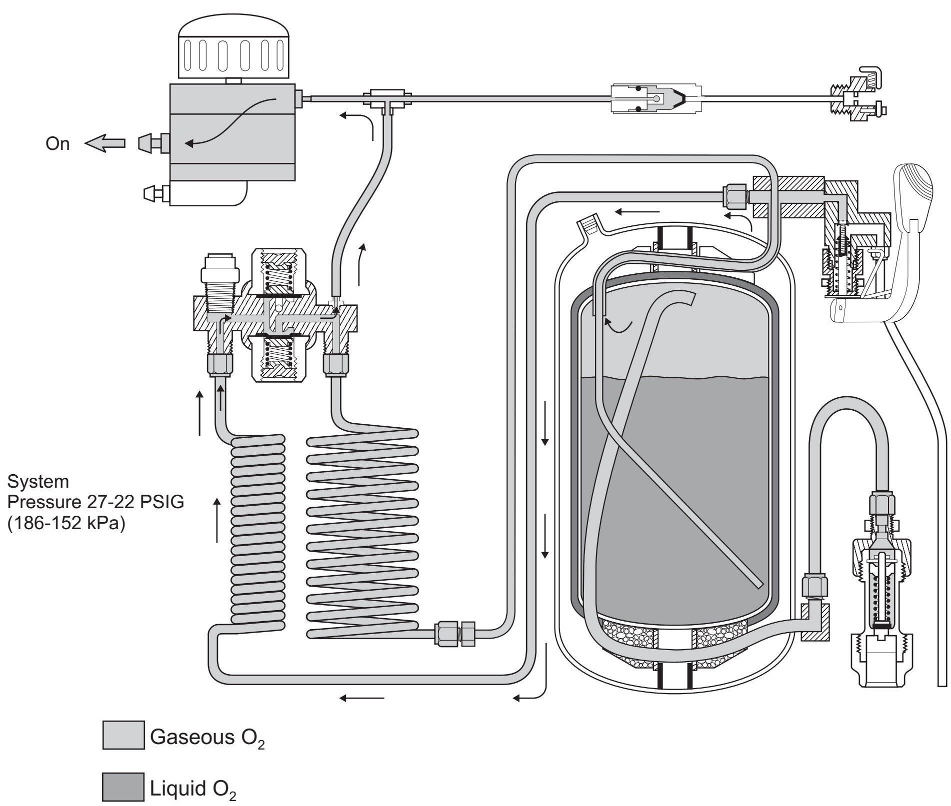


Figure 9-15: Oxygen Flow through Economizer Circuit

Once headspace pressure reaches 22 psig (152 kPa), the economizer valve spring force overcomes the opposing force created by the pressure acting on the valve diaphragm and closes down the valve. However, the economizer valve stays open just enough to allow the small flow of headspace gas created by the NER to pass through. Since this creates equilibrium where there is no net increase or decrease of gas in the headspace, system pressure remains constant at 22 psig (152 kPa). If the flow demand at the oxygen outlet is greater than the NER flow passing through the economizer valve, pressure at the outlet of the relief/economizer valve now drops below the headspace pressure acting on the surface of the liquid oxygen. The higher headspace pressure moves liquid oxygen up the liquid withdrawal tube and into the warming coil (Figure 9-16). The liquid oxygen vaporizes in the warming coil and the resulting oxygen flow combines with the small NER flow coming from the economizer valve. The combined total flow passes on to demand flow control valve at the desired rate. The H-300 remains at economizer pressure until the flow demand at the oxygen outlet stops.

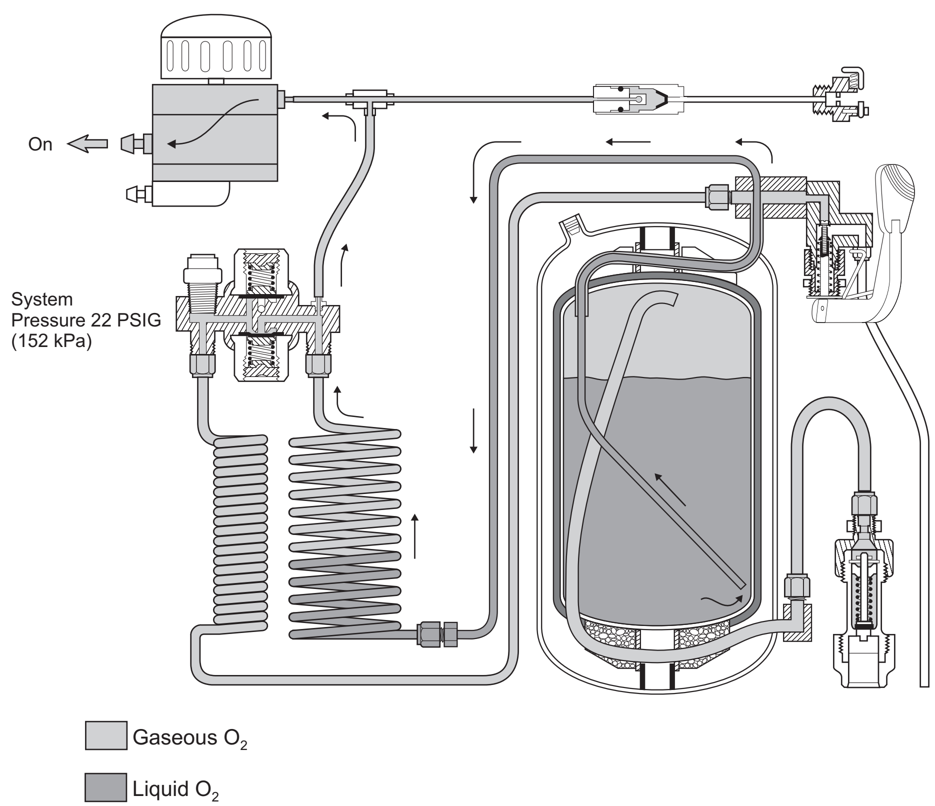


Figure 9-16: Oxygen Flow through Liquid Withdrawal Circuit

9.2.5 Gaseous Oxygen Use — H-300 Connected to Oxygen Supply Tube

During periods of sleep or other sedentary activities, the patient connects the H-300 to the Reservoir oxygen supply tube. The oxygen that the patient breathes from the H-300 comes directly from the Reservoir gaseous oxygen outlet (Figure 9-17). This keeps pressure in the Reservoir from building high enough to activate the Reservoir relief valve and vent gas to atmosphere. Evaporative oxygen loss from the Reservoir is substantially reduced or eliminated. For a complete description of how oxygen flow from the Reservoir occurs, refer to Reservoir Theory of Operation, Section 3.

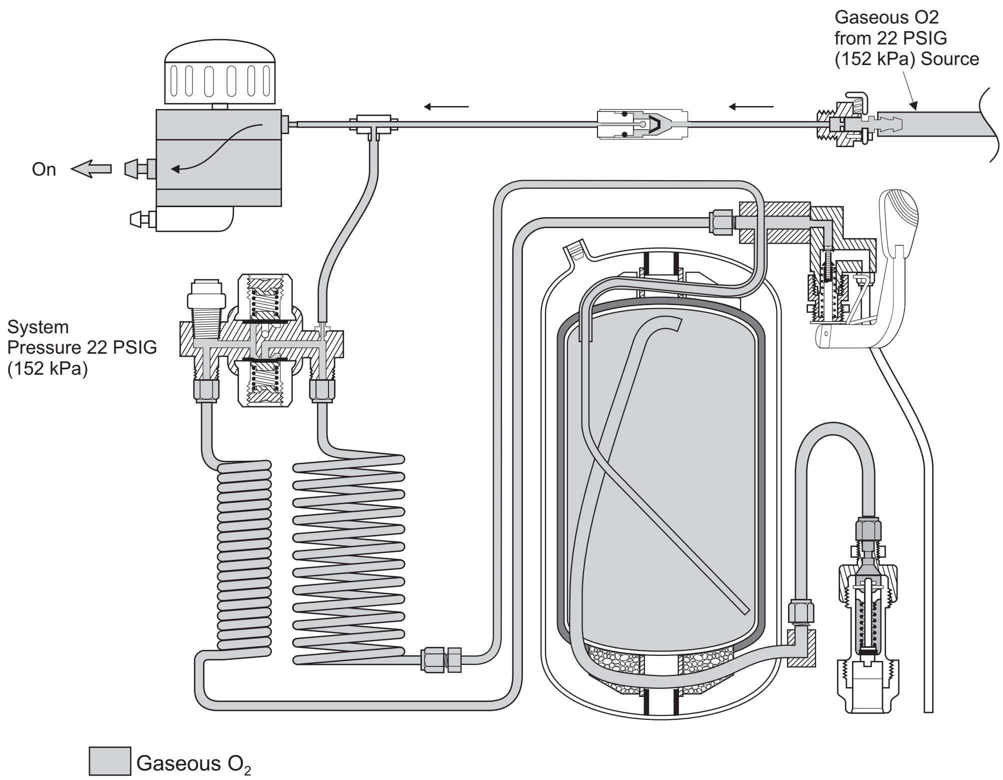


Figure 9-17: Oxygen Flow through Oxygen Supply Tube

Section **10**

HELiOS 300 PERFORMANCE VERIFICATION

This section provides testing information to verify H-300 performance for any of the following reasons:

- To determine the cause of operational failure.
- To check the unit's overall system operation after the repair or replacement of a component.
- To verify that the unit operates within specifications as a function of routine maintenance.

NOTE: Remove the H-300 side covers to conduct the performance verification tests.

10.1 EQUIPMENT REQUIRED

The following equipment is required to complete the performance verification tests in this section:

1) HELiOS Reservoir unit containing liquid oxygen saturated between 24 and 48 psig (166 and 331 kPa).
2) Portable test fixture (P/N B-778202-00).
3) Adjustable 0 to 100 psig (0 to 690 kPa) gaseous oxygen source.
4) Calibrated weight scale capable of accurately registering weight from 0-10 lb. (0-5 kg).
5) 0-100 psig test pressure gauge w/ tubing adapter (P/N B-701732-00).
6) Test flowmeter capable of accurately registering flows from 0 to 3 L/min.
7) Liquid leak detector – SNOOP (P/N B-775272-00).
8) Micro bar clamp (American Tool 6 in. Quick-Grip No. 53006).
9) Size 00 Rubber Stopper (VWR Scientific (800-932-5000) No. 59590-084 or equivalent).
10) T 10 Torx wrench.
11) Flexible tubing clamp or hemostat.
12) Jet/Venturi Assembly (P/N B-778210-00).
13) HELiOS oxygen supply tube (P/N B-701656-00).
14) HELiOS oxygen supply tube coupling (P/N B-701686-00).
15) Tie Wrap, 4-in./10 cm (P/N B-775091-00).
16) 3/16-in. x 4 ft. flexible tubing (P/N B-778214-00).
17) 2-in. spacer (for example, ¼-20 cap screw).

NOTE: It is important to use a calibration schedule for test equipment used for H-300 performance testing. Follow recommendations in Section 1.7, Test Equipment Calibration to ensure accurate test results.

NOTE: Do not use pressure gauges or flowmeters that have been dropped or mishandled. They must be calibrated before placing them back into service.

10.2 LEAK TESTS

Liquid oxygen leakage from the H-300 unit in any amount is unacceptable and calls for the immediate removal from service of any such leaking unit. Minor gas leaks in connections and fittings will not affect system operation provided they do not exceed the Normal Evaporation Rate (NER) of the unit. Two leak test procedures are described. Perform the Liquid Leak Detector Test to determine if any substantial leaks exist and where they are located. As an alternate test to determine if the H-300 total leak rate is acceptable, perform the Pressure Hold Test.

10.2.1 Liquid Leak Detector Test

Conduct the liquid leak detector test on an empty, pressurized unit that has warmed to room temperature. This test identifies the location of leaks in the H-300 by applying liquid leak detector to fittings, connectors, and joints and then looking for bubbles.

1. Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing still connected, next to the bottle assembly (Figure 10-1).

Figure 10-1: H-300 on Portable Test Fixture

2. Attach the test pressure gauge to the oxygen outlet (top) connector on the front side cover. Set the demand flow control knob to .75.

3. Attach the DISS nut and tailpiece of a HELiOS oxygen supply tube (P/N B-701656-00) to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen. Insert the oxygen supply tube coupling into the quick connect on the front side cover.

4. Increase the gaseous oxygen source pressure until the test pressure gauge reads 22-23 psig (152-159 kPa).

CAUTION: Do not apply leak detector to the vent port near the bottom of the demand flow control valve. Valve malfunction will occur.

5. Use the liquid leak detector to test all fittings, connections, and joints.

NOTE: Continually monitor the test pressure gauge while leak checking the H-300 to verify that the pressure in the system remains above 22 psig (152 kPa).

6. Wet a finger with leak detector and lightly place it against the open end of the vent tube near the bottom of the unit (Figure 10-2). If bubbling occurs, verify that the vent valve closes completely.

Figure 10-2: Leak Testing Vent Valve Outlet

7. Disconnect the HELiOS oxygen supply tube from the quick connect on the front side cover. Insert an open ended HELiOS oxygen supply tube coupling (P/N B-701686-00) into the quick connect on the front side cover. Wet a finger with leak detector and lightly place it against the open end of the coupling (Figure 10-3). If bubbling occurs, replace the inline check valve.

Figure 10-3: Leak Testing the Inline Check Valve

8. Repair/replace leaking fittings, connections, and components.

NOTE: If an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen is not available, the H-300 may be pressurized from a HELiOS Reservoir unit that is at operating pressure. Attach the DISS nut and tailpiece of the HELiOS oxygen supply tube to the DISS oxygen outlet on the Reservoir. Perform the leak test as previously described.

10.2.2 Pressure Hold Test (Alternate Leak Test)

Conduct the pressure hold test on an **empty** unit that has **warmed** to room temperature. Performing this test on an H-300 that contains liquid oxygen will yield inaccurate results. This test determines if the overall leak rate of the H-300 is excessive.

1. Attach the test pressure gauge to the oxygen outlet (top) connector on the front side cover. Set the demand flow control knob to .75.

2. Attach the DISS nut and tailpiece of a HELiOS oxygen supply tube (P/N B-701656-00) to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen. Insert the oxygen supply tube coupling into the quick connect on the front side cover.

3. Increase the gaseous oxygen source pressure until the test pressure gauge reads 24 psig (166 kPa). Disconnect the gaseous oxygen supply tube from the quick connect.

NOTE: If you do not get a reading on the pressure gauge, reset the demand valve as follows. Connect one tube of a dual lumen cannula to the H-300 sense connector. Adjust the cannula to your face and breathe once or twice.

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4. Allow the H-300 to sit for 10 minutes. Verify that the H-300 maintains a minimum pressure of 15 psig (104 kPa) at the end of the evaluation period. If the pressure drops below 15 psig (104 kPa), pressurize the unit to approximately 24 psig (166 kPa) and locate the leak by testing all components, fittings, and tubing with liquid leak detector. Make repairs as needed, taking care not to overtighten connections.

10.3 GASEOUS OXYGEN FUNCTIONAL TESTS

Conduct the following tests on an empty unit that has warmed to room temperature.

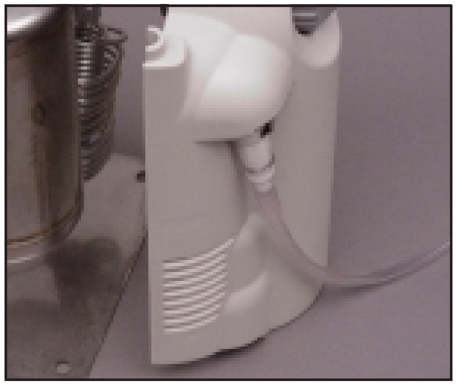
10.3.1 Primary Relief Valve Test

The primary relief valve maintains system pressure at a preset value when the H-300 contains liquid oxygen and is in the standby mode. The primary relief valve is part of the relief/economizer (R/E) valve. This test uses only gaseous oxygen to determine if the primary relief valve opens within its acceptable range.

1. Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing still connected, next to the bottle assembly (Figure 10-1).

2. Set the demand flow control valve to 0. Attach the DISS nut and tailpiece of a HELiOS oxygen supply tube (P/N B-701656-00) to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen. Insert the oxygen supply tube coupling into the quick connect on the front side cover (Figure 10-4 (a)).

3. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet. Connect the test pressure gauge tube to the vent valve barbed fitting and secure it with a tie wrap (P/N B-775091-00). Prop the vent valve lever in the open position with a 2-in. (5 cm) spacer (Figure 10-4 (b)).



(a)

(b)

Figure 10-4: Pressure Test Setup

4. Place one drop of leak detector on the R/E valve bronze vent port silencer disk (Figure 10-5). *Slowly* increase the gaseous oxygen source pressure until tiny, foam-like bubbles just begin to form on the surface of the silencer disk. Verify that the test pressure gauge reads 24-30 psig (166-207 kPa). If the opening pressure is not within the acceptable range, try adjusting the primary relief valve per H-300 Service and Repair, Section 12.6.3. Replace the R/E valve if you are unable to maintain primary relief valve pressure.

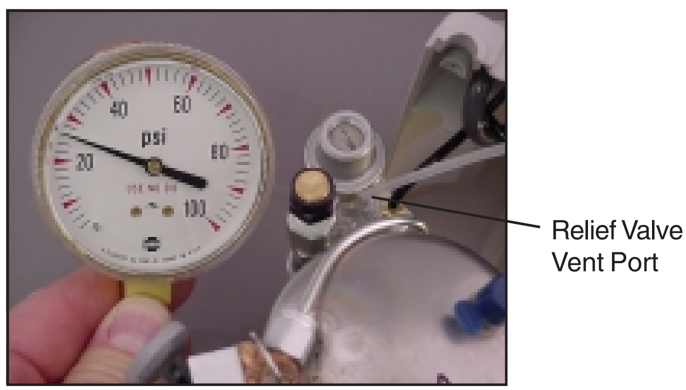


Figure 10-5: Testing Primary Relief Valve Venting

10.3.2 Secondary Relief Valve Test

The secondary relief valve serves as a safety or backup to the primary relief valve. Under normal operating conditions, the secondary relief valve remains closed. The relief valve opens if system pressure reaches 75-85 psig (518-587 kPa). This test uses only gaseous oxygen to determine if the secondary relief valve opens within its acceptable range.

1. Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing still connected, next to the bottle assembly (Figure 10-1).

CAUTION: Disconnect and clamp off the demand flow control valve oxygen inlet tube before performing the secondary relief valve test. High test pressure can damage the demand flow control valve.

2. Disconnect the 1/16-in. urethane tube from the demand flow control valve inlet barbed fitting (toward front of valve). Clamp the inlet tube with a tubing clamp or hemostat (Figure 10-6).

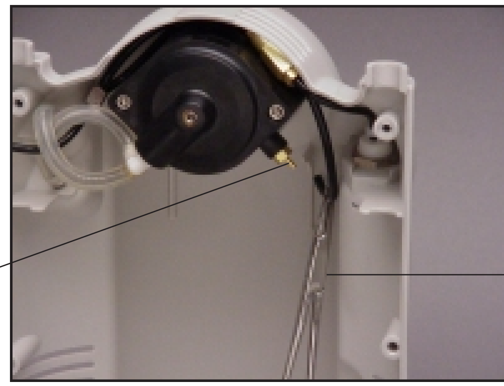
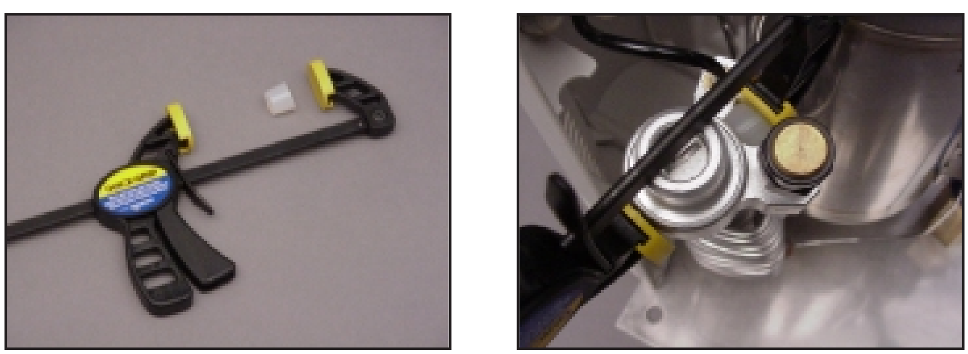


Figure 10-6: Disconnecting/Clamping Flow Control Valve Inlet Tube

3. Attach the DISS nut and tailpiece of a HELiOS oxygen supply tube (P/N B-701656-00) to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen. Insert the supply tube coupling into the quick connect on the front side cover (Figure 10-4 (a)).

4. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet. Connect the test pressure gauge tube to the vent valve barbed fitting and secure it with a tie wrap (P/N B-775091-00). Prop the vent valve lever in the open position with a 2-in. (5 cm) spacer (Figure 10-4 (b)).

5. Obtain a 6-in. Quick-Grip micro bar clamp and a size 00 rubber stopper (Figure 10-7 (a)). Trim the rubber stopper so that it is about 1/2-in. long. Place the smaller end of the rubber stopper over the R/E valve vent port. Position the bar clamp stationary arm on the larger end of the stopper and the movable arm on the R/E valve body (Figure 10-7 (b)). Tighten the clamp to seal the vent port.



(a) **(b)**

Figure 10-7: Bar Clamp Sealing R/E Valve Vent Port

6. *Slowly* pressurize the H-300 by adjusting the oxygen source regulator. Verify that the secondary relief valve opens (audible hiss) at 75-85 psig (518-587 kPa).

NOTE: If the secondary relief valve opens at a pressure slightly greater than 85 psig (587 kPa), reduce the oxygen source pressure to 50 psig (345 kPa). Release the tubing clamp or hemostat on the disconnected demand flow control valve inlet tube until the pressure in the H-300 drops to 50 psig (345 kPa). Re-clamp the inlet tube and repeat the test a second time. If the secondary relief valve fails to open within the acceptable range the second time, replace the valve per HELiOS 300 Service and Repair Section 12.7.

7. Reduce the oxygen source pressure to 0 psig/kPa and disconnect the oxygen supply tube from the quick connect on the front side cover. Disconnect the test pressure gauge from the vent valve barbed fitting and vent the pressure in the unit through the open vent valve. Connect the flexible vent tube to the vent valve barbed fitting. Remove the bar clamp blocking the R/E valve vent port. Remove the tubing clamp or hemostat and connect the 1/16-in. urethane oxygen inlet tube to the demand flow control valve barbed inlet fitting.

10.4 LIQUID OXYGEN FUNCTIONAL TESTS

Conduct the following tests on an H-300 that contains liquid oxygen saturated between 24 and 30 psig (166 and 207 kPa).

10.4.1 Contents Indicator Test

The contents indicator is a mechanical, spring-balanced weight scale mechanism that measures liquid oxygen contents when the H-300 is suspended from the indicator strap. The weight of the liquid oxygen in the H-300 determines the relative position of the indicator plate in the rear side cover window. This test verifies that the contents indicator operates smoothly and accurately.

NOTE: The H-300 must be completely assembled when performing this test.

1. Verify that the H-300 is empty and that nothing is attached to it.

2. Place the H-300 on a table and hold it down while gently pulling up on the contents indicator strap. Verify that the indicator operates smoothly and without binding.

3. Suspend the unit in the air by the contents indicator strap. Verify that the green indicator plate does not appear in the contents indicator window in the rear side cover.

4. Completely fill the H-300 with liquid oxygen (at least 0.9 lb./ 0.4 kg). Lift the H-300 by the contents indicator strap and push the bottom backside of the unit so that it is straight up and down. Verify that the green indicator plate completely fills the contents indicator window.

10.4.2 Normal Evaporation Rate (NER) Test

The NER test measures the insulation efficiency of the H-300 liquid oxygen container. The test results express in pounds (kilograms) the amount of liquid oxygen lost (converted into gaseous oxygen and vented through the relief valve) in a 24-hour period. Perform this test when one or more of the following symptoms exist:

a) Rapid loss of liquid oxygen contents from the container.
b) Heavy frost on the container.
c) Excessive venting of gaseous oxygen through the relief valve.

NOTE: Some venting of gaseous oxygen through the relief valve is normal.

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1. Make sure that the H-300 has been tested for leaks before continuing.

2. Set the demand flow control valve knob to 0 and fill the unit from a source of liquid oxygen saturated at 20-30 psig (138-207 kPa). Allow 1-2 hours for the unit to stabilize at primary relief valve pressure. The primary relief valve must be venting before continuing the test.

3. Record the initial weight of the unit and the time.

4. After an elapsed time of 5-6 hours, record the weight and time.

5. The NER may be calculated using the following formula:

$$\text{NER (lbs/kg per day)} = \frac{24\text{ (hr) x Weight Loss (lbs/kg)}}{\text{Elapsed Time (hr)}}$$

6. Verify that the NER is 1.5 lbs/day (0.68 kg/day) or less.

10.4.3 Economizer Test

The economizer valve establishes an operating pressure that allows a patient to breathe gas that would otherwise vent to atmosphere through the primary relief valve. Oxygen flow through the H-300 oxygen outlet must occur to establish the economizer operating pressure. The economizer valve is part of the relief/economizer (R/E) valve. This test verifies that the economizer valve maintains H-300 operating pressure within the acceptable range.

1. Make sure that the H-300 has been tested for leaks before continuing.

2. Set the demand flow control valve knob to 0 and fill the unit from a source of liquid oxygen saturated at 20-30 psig (138-207 kPa).

3. Keep the full H-300 in a vertical position and carefully remove the rear sidecover screws. Separate the rear side cover about 3/4-in. (2 cm) from the front sidecover and then slide it down about 3/4-in. (2 cm). **Make sure the vent valve does not open.** Rotate the sidecover counter clockwise until the vent valve lever can be pulled through the clearance opening in the rear sidecover.

4. Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing connected, next to the bottle assembly (Figure 10-1). Allow time (typically 30 minutes) for the unit to stabilize at primary relief valve pressure. The primary relief valve must be venting before continuing the test.

5. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet. Connect the test pressure gauge tube to the vent valve barbed fitting and secure it with a tie wrap (P/N B-775091-00). Prop the vent valve lever in the open position with a 2-in. (5 cm) spacer (Figure 10-4(b)). Verify that the test pressure gauge reads 24-30 psig (166-207 kPa) and that the primary relief valve is venting.

NOTE: The H-300 must be delivering continuous flow to test the economizer valve. The following steps use the jet/venturi assembly to ensure that the H-300 provides continuous flow for the economizer test.

6. Set the demand flow control knob to 2.

7. Use a short piece of 3/16-in. I.D. tubing to connect the jet/venturi assembly (P/N B-778210-00) to the sense (bottom) connector on the H-300 front side cover (Figure 10-8). Connect the DISS tubing adapter on the long tube of the jet/venturi assembly to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen.

CAUTION: Damage to demand flow control possible. Make sure you hook up the jet/venturi assembly exactly as shown in Figure 10-8. Do not block the open “bleeds” on the jet/venturi assembly.

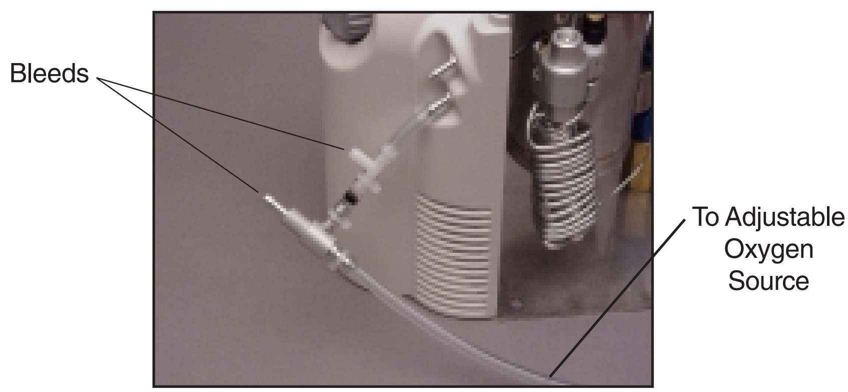


Figure 10-8: Connecting Jet/Venturi Assembly to Sense Connector

8. Increase the adjustable gaseous oxygen source pressure until you feel a continuous oxygen flow from the H-300 oxygen outlet connector. Check the reading on the test pressure gauge every five minutes until the pressure stabilizes. Stabilization occurs when two consecutive pressure readings are within 1 psig (7 kPa) of each other. The acceptable operating range for the economizer valve is 20.5-23.0 psig (141-159 kPa).

NOTE: If the economizer pressure is not within the acceptable range, try adjusting the economizer valve per H-300 Service and Repair, Section 12.6.3. Replace the R/E valve if you are unable to maintain economizer pressure.

10.4.4 Demand Flow Control Valve Test

The demand flow control valve is an oxygen conserving device that, when set from 1 to 4, provides demand flow oxygen to the patient only during each inspiration. Settings less than 1 provide continuous oxygen flow. A dual lumen cannula provides the patient interface. This test verifies that the valve's demand mode operation and continuous flow operation is within specification.

NOTE: Flow values listed in Table 10-1 were produced in ambient conditions of 70°F (21°C) and 29.4 in. Hg (74 mm Hg). Any deviation from these conditions will affect the flow results.

NOTE: Data listed in Table 10-1 is based on flowmeters with full-scale accuracy of 1% for flow ranges of 0.10 to 1.20 L/min. and 0.70 to 7.08 L/min. Using flowmeters with specifications other than those listed may produce different results.

NOTE: Data listed in Table 10-1 is based on an operating pressure range of 20.5 to 23.0 psig (141 to 159 kPa). If flow measurements are out of specification, check the pressure in the unit. A combination of high or low pressure and the tolerance of the particular flowmeter you are using can result in inaccurate readings.

1. Verify that the H-300 contains liquid oxygen and is at economizer pressure (20.5-23.0 psig/141-159 kPa).

2. Attach a length of 3/16-in. I.D. tubing (P/N B-778214-00) between the test flowmeter and the oxygen outlet (top) connector on the H-300 front side cover.

3. Check the *continuous* oxygen flow rate at settings .12, .25, .5, and .75. Verify that the flows are within the acceptable range listed in Table 10-1.

NOTE: If continuous flow does not occur at these flow settings, reset the demand valve as follows. Connect one tube of a dual lumen cannula to the H-300 sense connector. Adjust the cannula to your face and breathe once or twice. Oxygen should flow continuously from the oxygen outlet connector.

4. Set the demand flow control valve to 1 and verify that oxygen flow from the oxygen outlet connector stops (0 L/min on test flowmeter).

5. Disconnect the test flowmeter from the oxygen outlet connector. Use a short piece of 3/16-in. I.D. tubing to connect the jet/venturi assembly (P/N B-778210-00) to the sense (bottom) connector on the H-300 front side cover (Figure 10-8). Connect the DISS nut and tailpiece from the jet/venturi assembly to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen.

CAUTION: Damage to demand flow control possible. Make sure you hook up the jet/venturi assembly exactly as shown in Figure 10-8. Do not block the open "bleeds" on the jet/venturi assembly.

6. *Slowly* increase the adjustable gaseous oxygen source pressure until you feel a continuous oxygen flow from the H-300 oxygen outlet connector. Connect the test flowmeter to the oxygen outlet connector.

7. Check the demand inspiration *tailflow* oxygen flow rate at settings 1, 1.5, 2, 2.5, 3, 3.5, and 4. Verify that the flows are within the acceptable range listed in Table 10-1.

8. Disconnect the test flowmeter and the jet/venturi assembly from the connectors on the front side cover. Connect a new dual lumen cannula to the oxygen outlet and sense connectors.

9. Adjust the cannula to your face and breathe normally. At demand flow control settings from 1 through 4, verify that oxygen flow cycles on and off in response to your inspiration and exhalation. Verify that you sense a brief “puff” of oxygen at the beginning of each inspiration.

NOTE: If demand flow triggering sensitivity is in question, refer to H-300 Service and Repair, Section 12.8 for further testing and adjustment procedures.

TABLE 10-1. DEMAND FLOW CONTROL VALVE FLOW DATA

Flow Setting	Flow Measured	Specification (L/min)
0	None	0
.12	Continuous	0.12 (0.02-0.22)
.25	Continuous	0.25 (0.10-0.40)
.5	Continuous	0.50 (0.35-0.65)
.75	Continuous	0.75 (0.60-0.90)
1	Inspiration Tailflow	0.50 (0.35-0.65)
1.5	Inspiration Tailflow	0.65 (0.50-0.80)
2	Inspiration Tailflow	0.75 (0.60-0.90)
2.5	Inspiration Tailflow	1.00 (0.85-1.15)
3	Inspiration Tailflow	1.50 (1.30-1.70)
3.5	Inspiration Tailflow	1.75 (1.40-1.90)
4	Inspiration Tailflow	2.00 (1.70-2.30)

HELiOS 300 TROUBLESHOOTING

Section **11**

Table 11-1 provides troubleshooting procedures for the H-300. This guide is not all-inclusive but is intended to serve as a general outline for solving operational problems. The table describes symptoms, identifies probable causes, and suggests corrective actions.

When more than one probable cause is identified, the causes are listed in order of most likely to least likely reasons for the problem.

TABLE 11-1

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Liquid or gaseous oxygen leaks from fill connector after fill.	a. Ice crystal preventing proper closure of poppet. b. Damaged poppet or fill connector.	a. Engage and disengage mating fill connectors several times to dislodge ice crystal. If this fails, vent pressure in H-300 to stop leak. Blow dry all mating parts with dry nitrogen or oxygen gas. NOTE: May require at least 30 minutes at no flow to resaturate liquid oxygen in H-300. b. Examine poppet and fill connector. If damaged, replace cartridge assembly or fill connector per Section 12.4.
2. Liquid oxygen leaks from engaged fill connectors during fill.	a. Teflon lip seal in female fill connector cracked or damaged.	a. Replace lip seal per Section 12.4.
3. Unable to disconnect H-300 from Reservoir after fill.	a. Fill connectors frozen together due to presence of moisture.	a. Allow H-300 to sit until fill connectors warm enough to disconnect. (Fill connectors should be dried with lint-free cloth before filling.)

TABLE 11-1 (cont.)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
4. Unable to start fill or excessive fill time.	a. H-300 not properly engaged on Reservoir. b. Reservoir empty. c. H-300 vent tube restricted. d. Reservoir liquid oxygen saturation pressure low.	a. Make sure fill connectors properly aligned and H-300 *completely* engaged. b. Change or fill Reservoir. c. Verify vent valve tube not kinked or tube outlet not blocked. d. Allow liquid oxygen saturation pressure in Reservoir to build to 22 psig (152 kPa).
5. Vent valve fails to close (gas/liquid escaping from vent valve tube) after fill.	a. Vent valve frozen open.	a. Remove H-300 from Reservoir. Allow H-300 to warm until vent valve can close. Allow as much as 60 minutes to build adequate pressure for operation.
6. Excessive relief valve venting after fill.	a. Container vacuum loss. b. H-300 filled from Reservoir at 35-45 psig (242-311 kPa).	a. Perform NER test in Section 10. b. H-300 relief valve venting will subside after a few minutes.
7. H-300 will not maintain acceptable pressure in standby mode.	a. Gas leak in tubing or connections. b. Primary relief valve in R/E valve improperly adjusted or malfunctioning.	a. Perform leak test in Section 10. Repair as needed. b. Perform primary relief valve test in Section 10. Adjust primary relief valve per Section 12.6.
8. H-300 will not maintain acceptable pressure in flow delivery mode.	a. H-300 saturation pressure low. b. Economizer valve in R/E valve improperly adjusted or malfunctioning.	a. Allow liquid oxygen saturation pressure in H-300 to build to 22 psig (152 kPa). NOTE: May require at least 60 minutes at no flow to resaturate liquid oxygen in H-300. b. Perform economizer valve test in Section 10. Adjust/replace economizer valve per Section 12.6.
9. High liquid oxygen loss rate.	a. Leak in tubing or connections. b. Container vacuum loss.	a. Perform leak test in Section 10. Repair as needed. b. Perform NER test in Section 10.

TABLE 11-1 (cont.)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
10. H-300 stops pulsing during use.	a. Either dual lumen cannula tube not properly attached to connectors. b. Water droplets or other blockage in cannula nasal tips. c. Cannula tubing is kinked. d. Cannula tips not positioned properly in user's nose. e. H-300 is empty. f. User is breathing with mouth open. g. H-300 system pressure low. See steps 7 and 8.	a. Ensure both cannula tubes are firmly attached to connectors on H-300. b. Replace cannula with clean, dry one. c. Remove kink in cannula tubing. d. Ensure cannula tips remain in nostrils and do not slide to one side. e. Fill the H-300 with liquid oxygen. f. Close mouth and breathe only through nose. g. See steps 7 and 8.
11. Low flow at all flow control settings.	a. See Symptoms 7 and 8. b. Demand flow control valve inlet filter dirty. c. Partial obstruction in liquid oxygen withdrawal tube or warming coils. d. HELiOS oxygen supply tube restricted or leaking (if in use). e. Low pressure/low flow at Reservoir oxygen outlet (when H-300 and Reservoir connected by oxygen supply tube). f. Inline check valve restricting flow (when H-300 and Reservoir connected by oxygen supply tube).	a. See Symptoms 7 and 8. b. Remove and replace inlet filter. See Section 12.8. c. Check liquid withdrawal tube and warming coils for blockage. Clean or replace as needed. d. Check tube for restrictions or leaks. Clean or replace as needed. e. See Section 5, Symptom 9. f. Replace inline check valve.
12. No Flow	a. H-300 is empty. b. Zero head pressure caused by major leak (vent valve open, relief valve malfunction, etc.). c. Demand flow control valve inlet filter totally obstructed. d. Liquid withdrawal tube or warming coils totally obstructed. e. No pressure/flow at Reservoir oxygen outlet (when H-300 and Reservoir connected by oxygen supply tube).	a. Fill unit with liquid oxygen saturated at 22-27psig (152-186 kPa). b. Locate leak; repair as needed. c. Remove and replace inlet filter. See Section 12.8. d. Locate obstruction; clean or replace components as needed. e. See Section 5, Symptom 10.

Section 12

HELiOS 300 SERVICE AND REPAIR

This section provides procedures for servicing the individual components of the H-300. Included are instructions, where applicable, for removal, disassembly, operational check, cleaning, inspection, adjustment, reassembly, and installation.

WARNING

Personal injury can occur from the uncontrolled release of pressurized gaseous and liquid oxygen. Empty liquid oxygen contents and vent system pressure before servicing.

WARNING

Injury to eyes from flying objects possible. Wear eye protection when servicing the Portable.

After removing a component, visually inspect for damage or any other indication that the part should be replaced. Unless otherwise specified, replace as needed with a new part. Refer to the H-300 exploded view illustrations and parts list in Section 13.

NOTE: After making repairs, always verify proper system operation by performing the H-300 functional tests in Section 10.

12.1 EMPTYING AN H-300 UNIT

WARNING

Concentrated Oxygen. Increased risk of fire. Place unit in a well-ventilated area away from sources of ignition when setting a flow to empty unit.

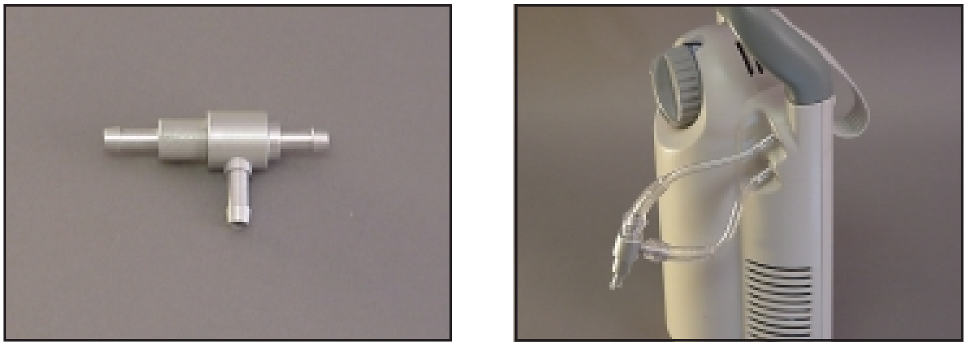
The liquid oxygen in an H-300 must be removed and the pressure reduced to atmospheric pressure before disassembling the unit for service. Also, the H-300 oxygen contents must be removed before packaging and shipping the unit. To remove the liquid oxygen from an H-300, you can set the demand flow control to .75 and allow the unit to run until empty. A full H-300 may take six to seven hours to empty using this method. To empty the H-300 in a shorter period of time (about two hours for a full unit), perform the following procedure.

1. Set the H-300 flow control to 4.

2. Take a dual lumen cannula and cut the tubes about 6 inches (15 cm) back from the end of the reinforced connectors. Attach the reinforced end of one tube to the jet/ venturi (P/N B-778213-00) bottom (suction) connector as shown in Figure 12-1. Attach

the opposite end to the H-300 bottom (sense) connector. Attach the reinforced end of the second tube to the jet/venturi shorter, right (oxygen inlet) connector as shown in Figure 12-1. Attach the opposite end to the H-300 top (oxygen outlet) connector. The jet/venturi longer, left (exhaust) connector must remain open.

CAUTION: Damage to demand flow control possible. Make sure you hook up the tubes exactly as shown in Figure 12-1. Do not block the open connector on the jet/venturi.



(a) **(b)**

Figure 12-1: Jet/Venturi Installation

3. Squeeze the tube connected to the sense connector on the H-300. You should hear and feel a continuous flow of oxygen coming from the open connector on the jet/venturi. The H-300 will deliver continuous oxygen flow until it is empty.

NOTE: Squeezing the sense tube creates a slight suction to open the demand valve and start oxygen flow. Oxygen flow through the jet/venturi maintains suction in the sense tube.

4. Once oxygen flow stops, pick up the H-300 by the contents indicator strap and verify that the contents indicator reads empty. Set the flow control to 0.

NOTE: A small residual amount of liquid oxygen may remain in the H-300 upon completion of the emptying procedure. The liquid oxygen will quickly vaporize into gas and build pressure. Open the vent valve to vent any residual pressure before servicing the H-300 or packaging it for shipment.

12.2 SIDE COVERS

The H-300 side covers are molded plastic components. When assembled, they form a clamshell-like enclosure for the H-300. The front side cover cradles the bottle assembly and the demand flow control valve. It is also the mounting point for the oxygen outlet connector and the sense connector. The rear side cover contains the contents indicator weight scale mechanism. It also contains clearance holes for the side cover retaining screws. The side covers and carrying handle are clamped together with screws that are inserted through the rear side cover and threaded into the front side cover.

12.2.1 Removal

1. Place the H-300 on its side with the rear side cover facing you. Use a T10 Torx driver to remove the Torx screws from the rear side cover.

2. Simultaneously pull both legs of the carrying handle away from the side covers.

3. Separate the rear side cover about 3/4-in. (2 cm) from the front sidecover and then slide it down about 3/4-in. (2 cm). Rotate the sidecover counter clockwise until the vent valve lever can be pulled through the clearance opening in the rear sidecover.

12.2.2 Disassembly - Front Side Cover

1. Carefully lift the bottle assembly up and away from the front side cover and place it on the table next to the side cover (Figure 12-2).

Figure 12-2: Bottle Assembly Removed from Front Side Cover

2. Remove the flow control knob by pulling it straight back from the font side cover. Pull the demand flow control valve back out of its seat in the front side cover.

3. Disconnect the two flexible silicone tubes from the oxygen outlet and sense connectors. Disconnect the 1/16-in. urethane tube from the inlet barb of the inline check valve.

4. Use a flat blade screwdriver to remove the C-clips that secure the oxygen outlet connector and the sense connector to the front side cover. Remove the connectors.

5. Use a 5/8-in. open-end wrench to remove the nut that secures the oxygen supply tube quick connect to the front side cover. Remove the quick connect and tube.

12.2.3 Reassembly - Front Side Cover

Reassemble the front side cover by reversing the disassembly procedure.

NOTE: Make sure that the two indexing pins on the front of the demand flow control valve engage the corresponding index holes in the front side cover. Center the bottle assembly in the front side cover mounting bosses.

12.2.4 Disassembly - Rear Side Cover

CAUTION: Do not overstretch the contents indicator springs. Over stretching the springs will cause inaccurate contents indication. Remove and install the springs by grasping spring at the hooked end with a needlenose pliers.

1. Disconnect the two contents indicator assembly spring from the spring hooks molded into the bottom of the rear side cover (Figure 12-3(a)).

2. Disconnect the two springs from the contents indicator assembly steel pull handle and indicator plate (Figure 12-3(a)).

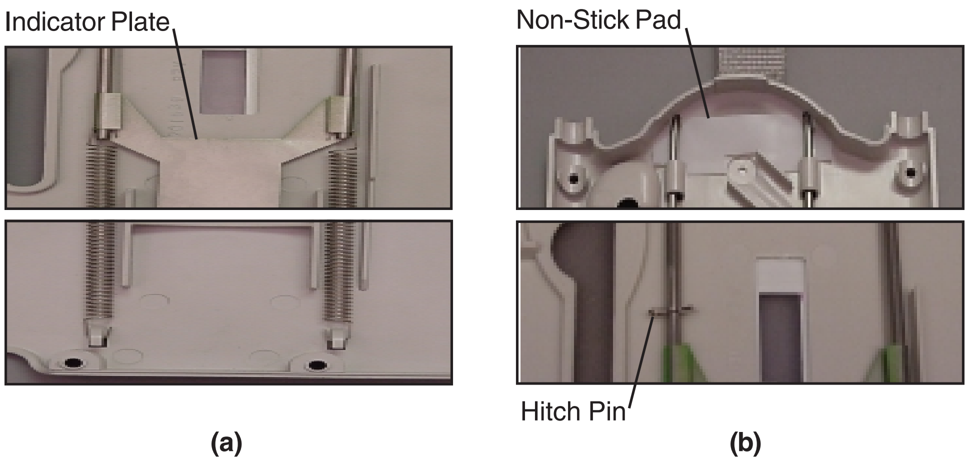


Figure 12-3: Disconnecting Spring from Pull Handle

3. Slide the indicator plate off the end of the steel pull handle.

4. Remove the hitch pin (if present) from the steel pull handle.

5. Slide the steel pull handle out the top of the rear side cover.

6. Remove the non-stick pad located above the two pull handle guides.

7. Remove the carrying strap from the steel pull handle.

12.2.5 Reassembly - Rear Side Cover

Reassemble the rear side cover by reversing the disassembly procedure.

NOTE: Install the steel pull handle so that the arm with two holes (if applicable) is nearest the vent lever opening. Insert (if applicable) the straight leg of the hitch pin through the *upper* hole in the pull handle until the pin snaps in place (Figure 12-3(b)). The open end of the hitch pin should face the center of the back cover.

NOTE: When installing the contents indicator springs, make sure that the open ends of the spring hooks face the center of the rear side cover. The top spring hooks must fit through the holes in the indicator plate arms and the steel pull handle. The non-stick pad must be in position behind the steel pull handle (Figure 12-3(b)).

NOTE: When replacing the rear side cover, be sure to install a new warning label. Current side covers use seven Torx screws.

12.2.6 Installation

Install the side covers by reversing the removal procedure.

NOTE: Fully seat the carrying handle in the side cover handle bosses. The handle should lean toward the front of the H-300. Use the two longer side cover screws in the top two screw holes. Do not over tighten the screws. Verify that the contents indicator moves freely and does not bind.

12.3 CONTENTS INDICATOR

The contents indicator is a mechanical, spring-balanced weight scale mechanism that measures the liquid oxygen contents in the H-300. The weight of the liquid oxygen in the H-300 determines the relative position of the indicator plate in the rear side cover window. Suspending the H-300 from the contents indicator strap moves the indicator plate into the indicator window. The position of the indicator in the window is proportional to the amount of liquid oxygen in the H-300.

12.3.1 Removal

Remove the rear side cover (Section 12.2.1).

12.3.2 Inspection

Carefully pull up on the contents indicator strap while holding the rear side cover. Verify smooth, unbinding movement of the contents indicator springs, pull handle, and indicator plate. Inspect the non-stick pad and indicator strap for signs of wear.

12.3.3 Disassembly and Reassembly

Perform the Disassembly procedure (Section 12.2.4) and Reassembly procedure (Section 12.2.5) for the rear side cover.

12.3.4 Installation

Install the rear side cover by reversing the removal procedure.

12.4 FEMALE FILL CONNECTOR AND TUBE

The female fill connector assembly is a special valved coupling that enables liquid oxygen to transfer from the Reservoir unit to the H-300. An internal cartridge assembly with a spring-loaded Kel-F poppet creates a pressure-tight seal when the female fill connector is not coupled to a Reservoir. When coupled, the female fill connector poppet lifts off its seat and allows liquid oxygen to flow. During the fill, a spring-energized Teflon lip seal prevents leakage between the female fill connector and the Reservoir male fill connector.

12.4.1 Removal

1. Remove the side covers (Section 12.2.1).

2. Use an adjustable wrench to hold the fill connector mounting bracket stationary. Use a 9/16-in. open-end wrench to remove the fill tube upper compression nut from the top of the fill connector (Figure 12-4).

Figure 12-4: Removing Fill Tube Upper Compression Nut

3. Use a 7/16-in. open-end wrench to hold the fill tube container fitting stationary. Use a 9/16-in. open-end wrench to remove the fill tube lower compression nut from the container fitting (Figure 12-5). Remove the fill tube.

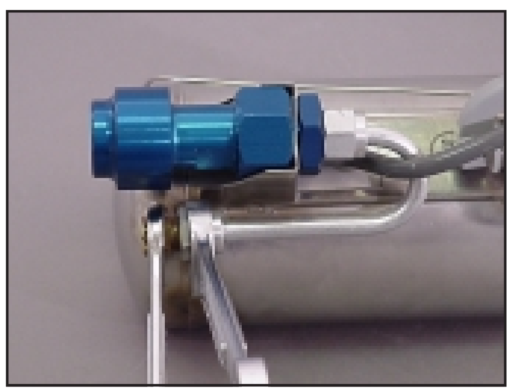
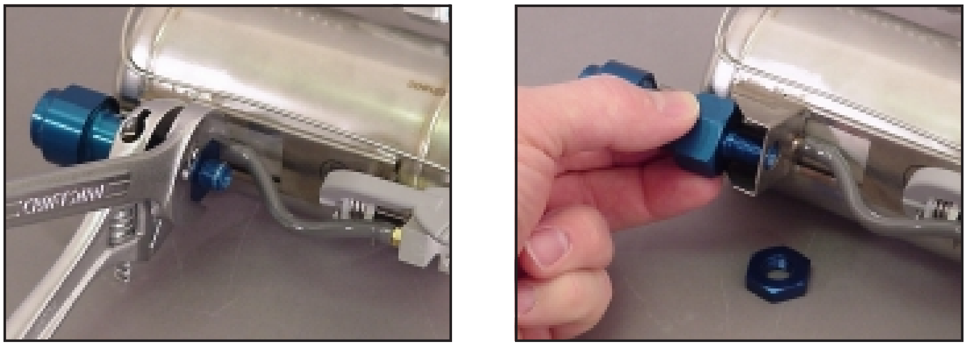


Figure 12-5: Removing Fill Tube Lower Compression Nut

4. Use an adjustable wrench to hold the fill connector mounting bracket stationary. Use a 7/8-in. open-end wrench to remove the jam nut from the fill connector assembly (Figure 12-6). Remove the fill connector assembly from the mounting bracket.



(a) (b)

Figure 12-6: Removing Fill Connector Assembly

12.4.2 Inspection

1. Inspect the Kel-F poppet on the cartridge assembly for wear, damage, or embedded contaminants.

2. Inspect the Teflon lip seal for wear or cracks.

3. Inspect the female adapter for cracks or scratches on the tapered seal surface of the fill tube connector.

12.4.3 Service

Service to the female fill connector assembly consists of replacing the female adapter and/or face seal, the lip seal, and the cartridge assembly. Refer to the following disassembly procedure to replace these items.

12.4.4 Disassembly

1. Place an 11/16-in. open-end wrench on the machined flats of the female quick connect body. Use an adjustable wrench to remove the female adapter (Figure 12-7).

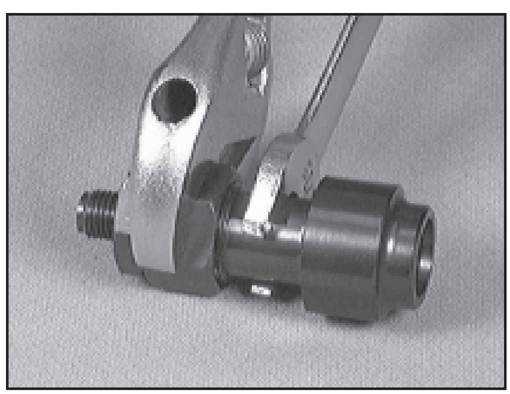


Figure 12-7: Removing Female Adapter

2. Use an awl or small screwdriver to remove the face seal from the female adapter (Figure 12-8).

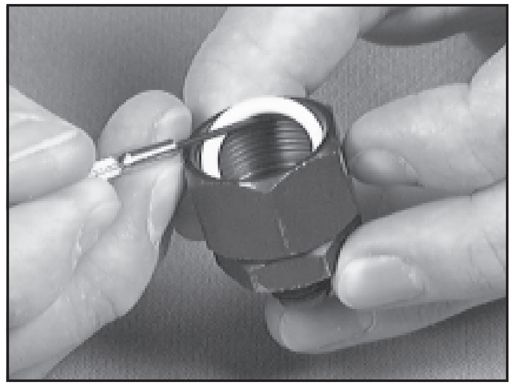
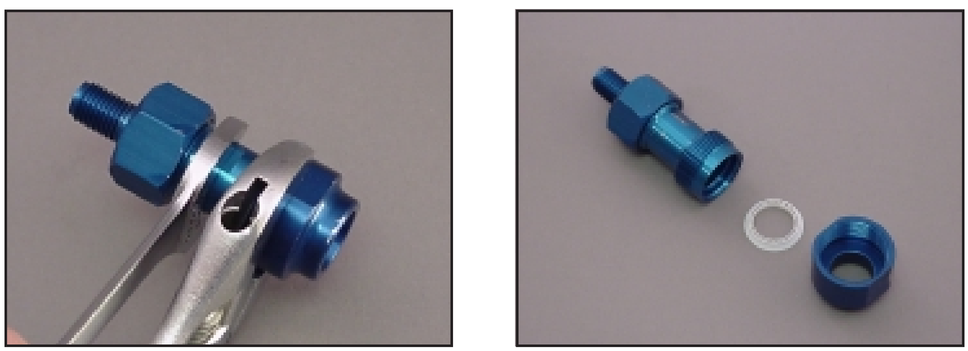


Figure 12-8: Removing Face Seal from Female Adapter

3. Hold the female quick connect body with an 11/16-in. open-end wrench placed on the machined flats. Use an adjustable wrench to remove the lip seal retainer sleeve. Pull the lip seal out of the female fill connector body (Figure 12-9).

NOTE: The stepped (spring) end of the lip seal fits into the corresponding recess in the female fill connector body.



(a) **(b)**

Figure 12-9: Removing Female Fill Connector Lip Seal

4. Use a small screwdriver or awl to remove the spiral retainer ring by first carefully lifting the beveled edge of the retainer ring over the lip of the retainer ring groove (Figure 12-10). Carefully pry the rest of the ring over the lip until the entire ring pops out.

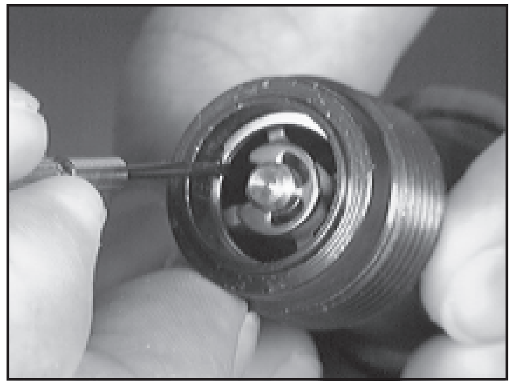


Figure 12-10: Removing Spiral Retainer Ring

5. Remove the cartridge assembly (Figure 12-11).

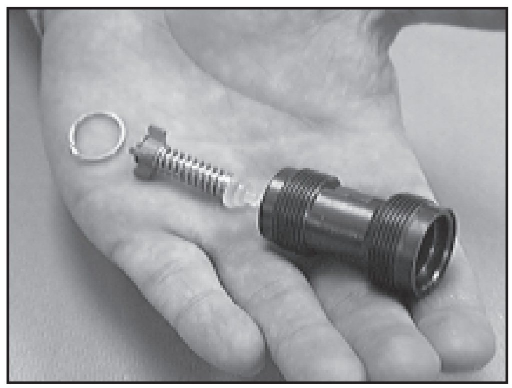


Figure 12-11: Cartridge Assembly

12.4.5 Reassembly

NOTE: Cartridge assembly installation requires the use of P/N B-775394-00 female fill connector installation sleeve (marked "F") and P/N B-775392-00 inner installation tool (marked "I").

1. Insert the cartridge assembly into the female fill connector body.

2. Place the larger (lip seal) end of the fill connector body flat on a table. Place the stepped end of the installation sleeve (marked "F") on the smaller (face seal) end of the quick connect.

3. Place the spiral retainer ring into the open end of the installation sleeve (Figure 12-12).

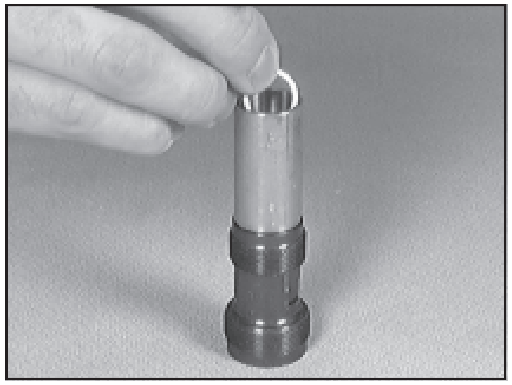


Figure 12-12: Inserting Spiral Retainer Ring into Female Installation Sleeve

4. Firmly hold the fill connector and female installation sleeve together. Insert the rounded end of the inner installation tool (marked "I") into the female sleeve and push the retainer ring down until you feel it "click" into place (Figure 12-13).

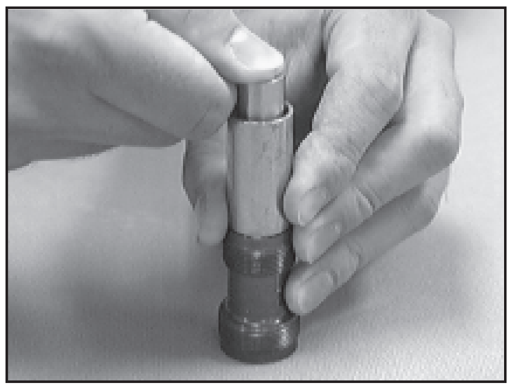


Figure 12-13: Seating Spiral Retainer Ring

5. Remove the tools and visually inspect the assembly to ensure that the retaining ring is positioned correctly.

6. Insert the stepped (spring) end of the lip seal into the corresponding recess in the large end of the female fill connector body. Make sure that it is squarely seated (Figure 12-14)

Figure 12-14: Installing Lip Seal

7. Thread the lip seal retainer onto the large end of the female fill connector body and tighten to a torque of 35 lb/ft (511 n/m).

8. Install a new female adapter seal on the small end of the female fill connector body. Thread the female adapter onto the body and tighten to a torque of 35 lb/ft (511 n/m).

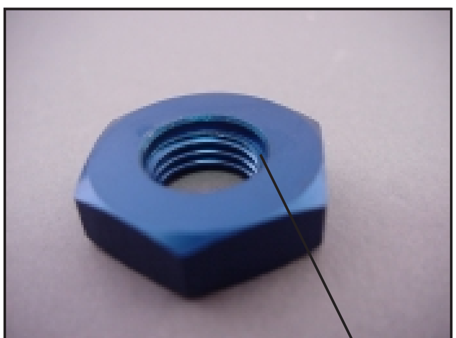
12.4.6 Installation

Install the female fill connector and tube by reversing the removal procedure.

NOTE: The internal threads in the fill connector jam nut do not run completely through the nut. Install the fill connector jam nut with the unthreaded end toward the mounting bracket (Figure 12-15).

NOTE: With the fill connector positioned in its mounting bracket, use an adjustable wrench to hold the fill connector mounting bracket stationary. Use a torque wrench to tighten the jam nut to 20 lb-ft (292 N-m) torque.

NOTE: Position the fill tube so that the ferrules on each end are seated in their fittings on the fill connector and the container. Alternately hand-tighten the fill tube nuts to seat the ferrules evenly. Use two wrenches to tighten the nuts securely *per instructions in Section 1.5.2.*



Unthreaded End

(a) (b)

Figure 12-15: Fill Connector Jam Nut Threads

12.5 VENT VALVE AND TUBE

The vent valve is a lever-operated, spring loaded poppet valve that you open to fill an H-300 and close to terminate the fill.

12.5.1 Removal

NOTE: The coil type vent lever spring, plastic spacer, and vent lever used on early H300 units are no longer available. Current vent valves use a torsion type vent lever spring, a Teflon washer, and a new vent lever design.The new components have new part numbers but are backward compatible with all early H300 vent valves.

1. Remove the side covers (Section 12.2.1).

2. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet.

3. Remove the torsion spring by lifting the curved end of the long spring arm off of the vent valve barbed fitting. Remove the spring from the vent lever hub (current valves).

4. Use a ¼-in. open-end wrench to remove the vent tube barbed fitting.

5. Use a 5/8-in. open-end wrench to hold the vent valve large hex nut stationary. Use a 11/16-in. open-end wrench to loosen the jam nut that holds the vent valve to the mounting bracket (Figure 12-16).

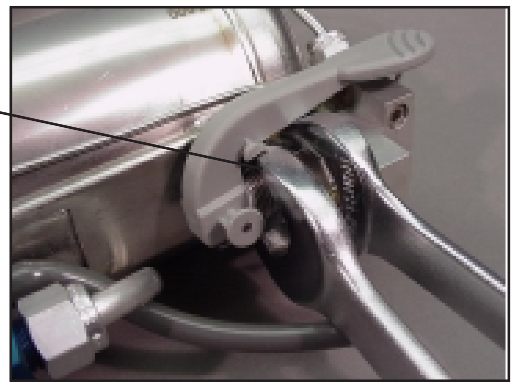


Figure 12-16: Loosening Vent Valve Jam Nut

6. Use a 7/64-in. hex key wrench to remove the two vent valve screws and lock washers. Slide the vent valve out of the mounting bracket.

12.5.2 Inspection

1. Inspect the vent valve O-ring seal for cuts, debris, wear, or flatness. Replace the O-ring as needed (Figure 12-17).

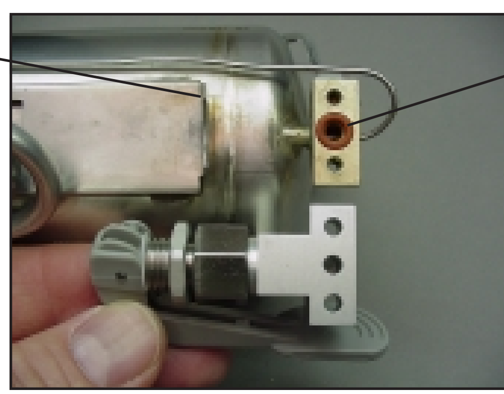


Figure 12-17: Vent Valve O-ring Seal

2. Inspect the vent valve lever**,** washer**,** and torsion spring for wear, cracks, or other damage. Temporarily install the barbed fitting and torsion spring on the valve (Figure 12-18). Make sure that the valve operates smoothly. The valve should return to the closed position when the lever is released.

Figure 12-18: Vent Valve Assembly

3. Inspect the flexible vent tube for damage. Inspect the seal in the barbed fitting for wear or damage.

12.5.3 Service

Service to the vent valve consists of replacing the O-ring seal, the lever, the lever pin, the Teflon washer, the torsion spring, and the barbed fitting. Refer to the following disassembly procedure to replace these items.

NOTE: Early style vent valve levers, washers, and springs are no longer available. If one of these items needs to be replaced, you must upgrade completely to the current style lever, washer, and spring.

12.5.4 Disassembly

1. Locate a suitable support block about ½-in. thick to support the end of the vent valve lever (Figure 12-19). Use a pin punch or hex key wrench to push out the lever pin.

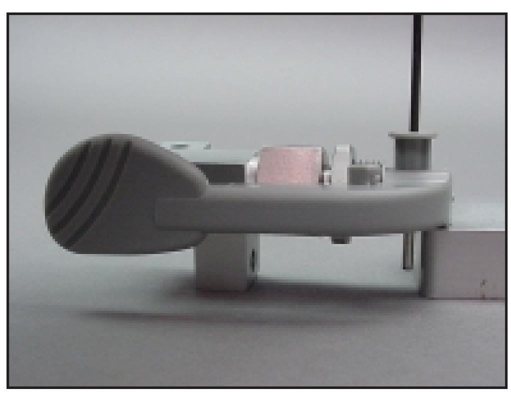


Figure 12-19: Removing Vent Valve Lever Pin

2. Remove the lever and Teflon washer (Figure 12-20).

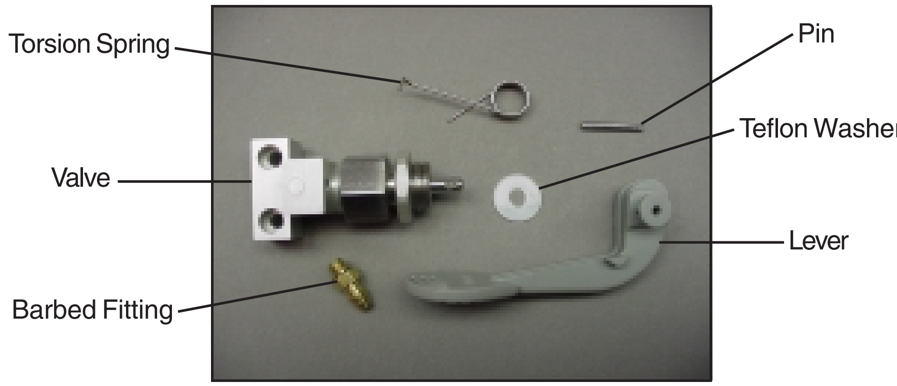


Figure 12-20: Disassembled Vent Valve Components

12.5.5 Reassembly

Reassemble the vent valve by reversing the disassembly procedure.

NOTE: Place the Teflon washer over the valve shaft and then align the hole in the valve shaft with the hole in the vent lever. Insert the pin into the hole in the vent lever opposite the lever hub. Use a pliers to press the pin completely through the valve shaft and lever.

12.5.6 Installation

Install the vent valve by reversing the removal procedure.

NOTE: Install the vent valve lock washers and screws first, tightening them evenly in an alternating sequence. Then secure the vent valve to the mounting bracket with the jam nut. Insert the torsion spring over the lever hub with the short end of the spring closest to the lever.Make sure to push the flexible vent tube completely onto the vent valve barbed fitting.

12.6 RELIEF/ECONOMIZER VALVE

The relief/economizer (R/E) valve is a pressure regulating device that combines the function of a primary relief valve and an economizer valve into one component. The primary relief valve establishes the maximum pressure achievable in the H-300 during standby. The economizer valve establishes a lower operating pressure when a patient breathes oxygen from the unit. This enables a patient to breathe gas that would otherwise vent to atmosphere through the primary relief valve. The R/E valve is not field repairable. However, the R/E valve pressure settings may be adjusted if they are out of range.

12.6.1 Removal

1. Remove the side covers (Section 12.2.1).

2. Remove the flexible urethane tube from the barbed fitting on the R/E valve outlet arm. Use a 1/4-in. open-end wrench to remove the barbed fitting.

3. Use an adjustable wrench to hold the R/E valve inlet arm stationary (Figure 12-21). Use a 7/16-in. open-end wrench to remove the economizer warming coil compression nut from the inlet arm fitting. Pull the economizer warming coil tube out of the fitting.

Figure 12-21: Disconnecting Economizer Tube from R/E Valve

4. Use an adjustable wrench to hold the R/E valve outlet arm stationary. Use a 7/16-in. open-end wrench to remove the liquid withdrawal warming coil compression nut from the outlet arm fitting. Pull the liquid withdrawal warming coil tube out of the fitting.

5. Use an adjustable wrench to hold the R/E valve inlet arm stationary. Use a ½-in. open-end wrench to remove the secondary relief valve.

12.6.2 Installation

CAUTION: High pressure hazard. Over tightening the secondary relief valve can cause it to operate improperly. Do not over tighten the valve. Perform Secondary Relief Valve Test in Section 10.3.2.

1. Apply Teflon tape sealant to the secondary relief valve threads. Install the secondary relief valve in the R/E valve inlet arm port and tighten until snug.

2. Insert the economizer warming coil tube in the R/E valve inlet arm fitting and finger-tighten the compression nut. The economizer warming coil is the smaller diameter coil. Insert the liquid withdrawal warming coil tube in the R/E valve outlet arm port and finger-tighten the compression nut.

3. Tighten both compression nuts using a 7/16-in. open-end wrench on the nuts and an adjustable wrench on the corresponding R/E valve arms.

NOTE: The R/E valve arms should face the container.

4. Install the barbed fitting in the R/E valve outlet arm. Install the flexible urethane tube on the barbed fitting.

5. Install the side covers (Section 12.2.1).

12.6.3 R/E Valve Adjustment

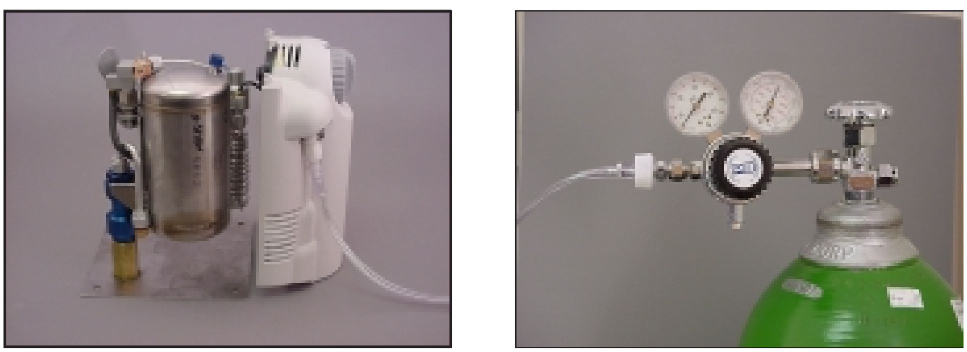
If the primary relief valve or the economizer valve is operating at a pressure out of its acceptable range, it may be possible to adjust the setting of the valve. Carefully perform the following steps to adjust the pressure setting for the appropriate valve.

NOTE: Before making any R/E valve adjustments, verify that perceived pressure problems are not the result of other H-300 functional problems.

Adjusting the Primary Relief Valve

1. Remove the side covers (Section 12.2.1). Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing still connected, next to the bottle assembly.

2. Attach the DISS nut and tailpiece of a HELiOS oxygen supply tube (P/N B-701656-00) to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen. Insert the oxygen supply tube coupling into the quick connect on the front side cover (Figure 12-22).



(a) **(b)**

Figure 12-22: Pressurizing the Portable

3. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet. Connect the test pressure gauge tube to the vent valve barbed fitting and secure it with a tie wrap (P/N B-775091-00). Prop the vent valve lever in the open position with a 2-in. (5 cm) spacer (Figure 12-23).

Figure 12-23: Test Pressure Gauge Setup

4. Place one drop of leak detector on the R/E valve vent port silencer (Figure 12-24). *Slowly* increase the gaseous oxygen source pressure until tiny, foam-like bubbles first appear at the surface of the bronze vent port silencer disk. Verify that the test pressure gauge reads 24-30 psig (166-207 kPa).

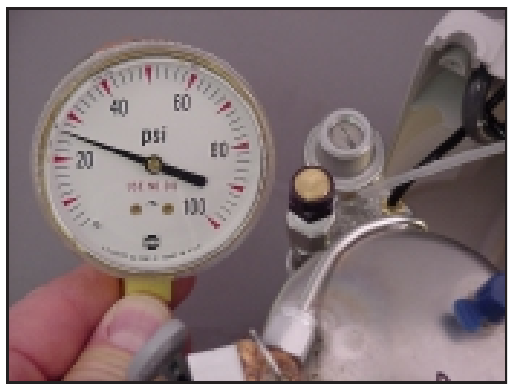


Figure 12-24: Applying Snoop to R/E Valve Vent Port

5. If the primary relief valve pressure is low, turn the primary relief valve adjustment screw a quarter turn clockwise (in) and repeat step 4. The primary relief valve adjustment screw is located at the top of the R/E valve (Figure 12-25).

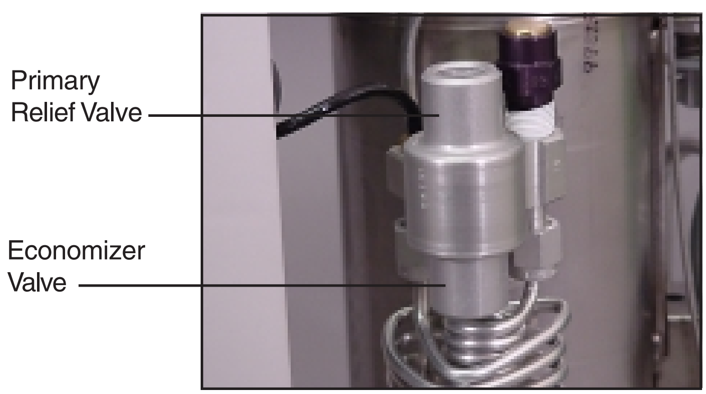


Figure 12-25: Primary Relief Valve/Economizer Valve Adjustment

6. If the primary relief valve pressure is high, reduce the pressure in the H-300 to below 20 psig (138 kPa). Turn the primary relief valve adjustment screw a quarter turn counter clockwise (out) and repeat step 4.

NOTE: To reduce pressure in the H-300, reduce the adjustment on the pressurizing source regulator. Set the demand flow control valve to .75 until the test pressure gauge reads less than 20 psig (138 kPa). Set the demand flow control valve to 0.

Adjusting the Economizer Valve

WARNING

Extreme cold hazard. Some exposed parts of the container assembly will get extremely cold. Wear protective gloves when filling.

7. Remove the rear sidecover (Section 12.2.1). Set the demand flow control valve knob to 0. Keep the H300 container assembly nestled in the front side cover and fill the unit from a source of liquid oxygen saturated at 20-30 psig (138-207 kPa).

8. Set the H-300 bottle assembly on the portable test fixture. Stand the front side cover, with tubing connected, next to the bottle assembly (Figure 10-1). Allow time (typically 30 minutes) for the unit to stabilize at primary relief valve pressure. The primary relief valve must be venting before continuing.

9. Disconnect the flexible vent tube from the barbed fitting at the vent valve outlet. Connect the test pressure gauge tube to the vent valve barbed fitting and secure it with a tie wrap (P/N B-775091-00). Prop the vent valve lever in the open position with a 2-in. (5 cm) spacer (Figure 12-23). Verify that the test pressure gauge reads 24-30 psig (166-207 kPa) and that the primary relief valve is venting.

NOTE: The H-300 must deliver continuous flow to test and adjust the economizer valve. Steps 10-12 describe how to create a continuous flow state in the H-300.

10. Set the demand flow control knob to 2.

11. Use a short piece of 3/16-in. I.D. tubing to connect the jet/venturi assembly (P/N B-778210-00) to the sense (bottom) connector on the H-300 front side cover (Figure 10-8). Connect the DISS nut and tailpiece from the jet/venturi assembly to an adjustable 0-100 psig (0-690 kPa) source of gaseous oxygen.

CAUTION: Damage to demand flow control possible. Make sure you hook up the jet/venturi assembly exactly as shown in Figure 10-8. Do not block the open "bleeds" on the jet/venturi assembly.

12. Increase the adjustable gaseous oxygen source pressure until you feel a continuous oxygen flow from the H-300 oxygen outlet connector. Record the reading on the test pressure gauge every five minutes. The pressure has stabilized when two consecutive pressure readings are within 1 psig (7 kPa) of each other. Verify that the stabilized pressure is 20.5-23.0 psig (141-159 kPa).

13. If the economizer pressure is low, turn the economizer valve adjustment screw a quarter turn clockwise (in). The economizer valve adjustment screw is located at the bottom of the R/E valve (Figure 12-25). Record pressure readings every five minutes until the pressure stabilizes. Repeat this step as needed to reach the specified range.

14. If the economizer pressure is high, turn the economizer valve adjustment screw a quarter turn counter clockwise (out). Record pressure readings every five minutes until the pressure stabilizes. Repeat this step as needed to reach the specified range.

12.7 SECONDARY RELIEF VALVE

The secondary relief valve is a poppet-type pressure control valve that acts as a safety backup in the event that the primary relief valve fails to limit system pressure to an acceptable range. Under normal operating conditions, the secondary relief valve remains closed. The secondary relief valve is not field serviceable or adjustable.

12.7.1 Removal

1. Remove the side covers (Section 12.2.1).

2. Use an adjustable wrench to hold the R/E valve inlet arm stationary (Figure 12-21). Use a ½-in. open-end wrench to remove the secondary relief valve.

12.7.2 Installation

CAUTION: High pressure hazard. Over tightening the secondary relief valve can cause it to operate improperly. Do not over tighten the valve. Perform Secondary Relief Valve Test in Section 10.3.2.

1. Apply Teflon tape sealant to the secondary relief valve threads. Install the secondary relief valve in the R/E valve inlet arm port.

2. Use an adjustable wrench to hold the R/E valve stationary. Use a ½-in. open-end wrench to tighten the secondary relief valve until snug.

3. Install the side covers (Section 12.2.1).

12.8 DEMAND FLOW CONTROL VALVE

The demand flow control valve is an oxygen conserving device that, when set from 1 to 4, provides demand flow oxygen to the patient only during each inspiration. Settings less than 1 provide continuous oxygen flow. A dual lumen cannula provides the patient interface.

12.8.1 Removal

1. Remove the side covers (Section 12.2.1).

2. Remove the flow control knob by pulling it straight back from the front side cover. Pull the demand flow control valve back out of its seat in the front side cover.

3. Use a small flat blade screwdriver to carefully pry the 1/16-in. urethane tube off of the demand flow control valve inlet barbed fitting.

4. Use a small flat blade screwdriver to carefully pry the 1/8-in. silicone tubes off of the demand flow control valve outlet and sense barbed fittings.

12.8.2 Service

CAUTION: The demand flow control valve is manufactured to exacting tolerances and uses a number of small orifices. Ensure that hands, tools, and work table are clean when working with the valve. Do not allow liquids to enter the vent port located directly across from the valve inlet fitting.

The demand flow control valve is not field serviceable. The barbed fittings, detent springs, and inlet filter screen may be replaced as needed. When replacing the filter screen, remove the inlet barbed fitting and hold the valve so that the inlet port faces down. Use a dental pick or similar tool to carefully remove the inlet filter screen from the inlet port (Figure 12-26).

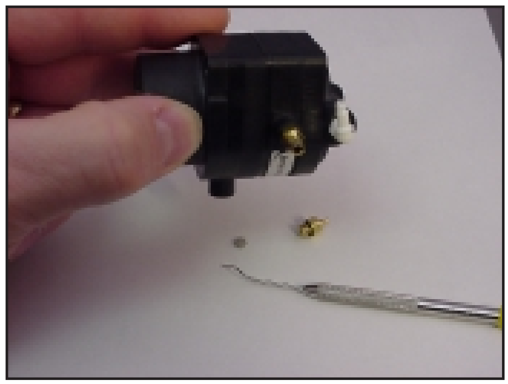


Figure 12-26: Removing Demand Flow Control Valve Filter Screen

NOTE: Push the replacement filter screen into the inlet port until seated on the internal support ledge. Do not install two screens as this may cause a restriction to flow.

NOTE: When installing the brass barbed fittings, verify the presence and condition of the seal gasket on the threaded end of the fittings.

12.8.3 Installation

Install the demand flow control valve by reversing the removal procedure.

12.8.4 Sensitivity Adjustment

Refer to Figure 12-27 for the test setup required to test and adjust the demand valve sensitivity.

CAUTION: Damage to demand flow control valve possible. One port of the jet/venturi assembly tee connector (Figure 12-27) and the long port of the jet/venturi act as bleeds and must remain open.

NOTE: The Magnehelic gauge must be leveled and zeroed in the vertical position before making any adjustments to the demand flow control valve. Check the gauge calibration periodically according to the manufacturer's specifications or if it has been dropped or mishandled.

1. Make sure that the H-300 has been tested for leaks before continuing.

2. Set the demand flow control valve knob to 0 and fill the unit with liquid oxygen saturated at 22-27 psig (152-186 kPa). Let the system pressure stabilize for 10 minutes.

3. Connect the jet/venturi test setup shown in Figure 12-27 to the H-300 sense (bottom) connector. Connect the test flowmeter to the oxygen outlet (top) connector.

4. Set the demand flow control valve to 4. Increase the oxygen source pressure to the jet/venturi assembly until approximately 2 L/min of flow registers on the test flowmeter. Let the unit run at this flow for five minutes. This will bring the system pressure down to the economizer setting (20.5-23.0 psig/141-159 kPa).

5. Decrease the oxygen source pressure to the jet/venturi assembly to 0 psig. The test flowmeter should read 0 L/min and the Magnehelic gauge should read 0 in. H2O.

6. With the Magnehelic gauge reading 0 in. H2O, S-L-O-W-L-Y increase the oxygen source pressure to the jet/venturi assembly until oxygen flow (at least .25 L/min) first registers on the test flowmeter. Verify a pressure reading of .038-.043 in. H2O vacuum on the Magnehelic gauge.

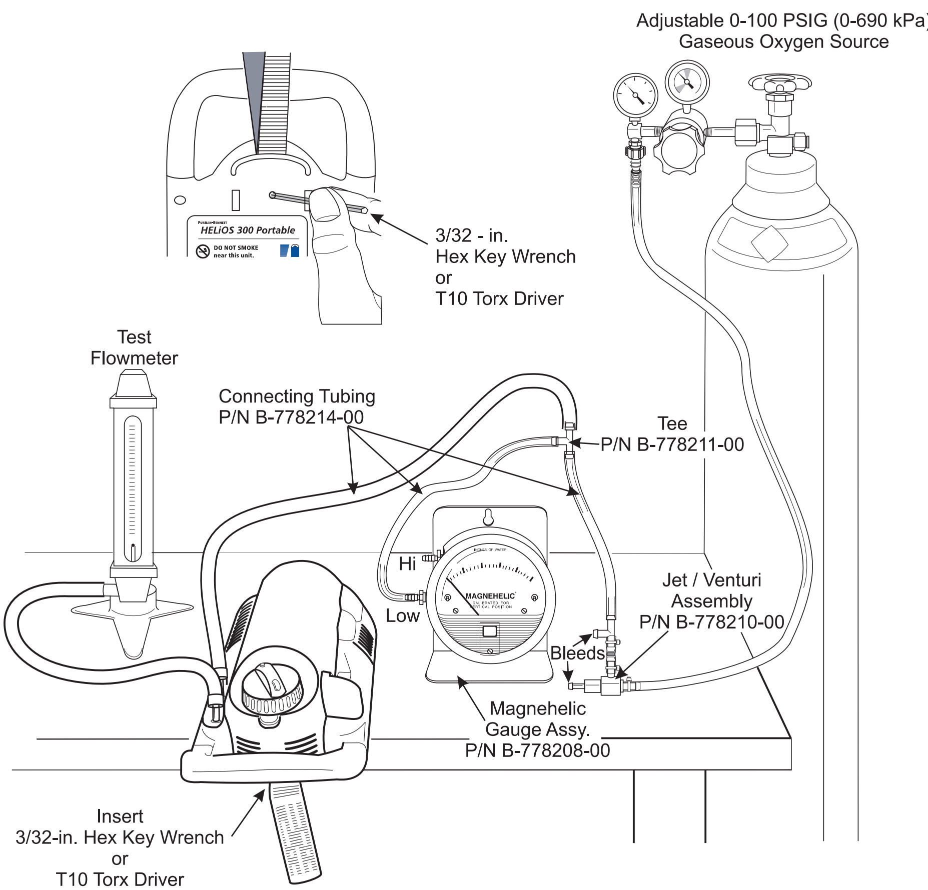


Figure 12-27: Portable Demand Flow Control Valve Test Setup

7. If the Magnehelic gauge reads less than .038 in. H2O when oxygen flow first registers in step 6, adjust the demand flow control valve as follows. With the H-300 laying flat on the work table, position the top one third of the unit over the edge of the table. Insert a 3/32-in. hex key wrench (earlier units) or T10 Torx driver (current units) through the small hole in the H-300 rear side cover above the contents indicator window. S-L-O-W-L-Y turn the demand flow control valve set screw about 1/16 turn clockwise. Repeat steps 6 and 7 until you achieve the desired results in step 6.

8. If the Magnehelic gauge reads more than .043 in. H2O when oxygen flow first registers in step 6, adjust the demand flow control valve as follows. With the H-300 laying flat on the work table, position the top one third of the unit over the edge of the table. Insert a 3/32-in. hex key wrench or T10 Torx driver through the small hole in the H-300 rear side cover above the contents indicator window. S-L-O-W-L-Y turn the demand flow control valve set screw about 1/16 turn counter clockwise. Repeat steps 6 and 8 until you achieve the desired results in step 6.

9. Increase the adjustable oxygen pressure regulator until the Magnehelic gauge reads .080 in. H2O. Verify that the test flowmeter reads about 2 L/min. Decrease the regulator pressure until the Magnehelic gauge reads 0 in. H2O. Verify that the test flowmeter reads 0 L/min.

10. Disconnect the test setup from the H-300 and connect a new dual lumen cannula to the H-300 oxygen outlet and sense connectors. Adjust the cannula to your face and breathe normally. Verify that oxygen flow distinctly cycles on during inspiration and off during exhalation.

11. Cycle the demand flow control valve 25 times with the dual lumen cannula connected. Disconnect the cannula and verify that there is no flow through the oxygen outlet connector.

12. Connect the test setup shown in Figure 12-27. Repeat step 6 and verify that the demand flow control valve sensitivity is in the acceptable range.

12.9 WARMING COILS

Two warming coils are used in the H-300. They act as heat exchangers to vaporize liquid oxygen into gaseous oxygen and to warm very cold gaseous oxygen. The liquid withdrawal (large loop) warming coil vaporizes liquid oxygen when the H-300 delivers flow at economizer pressure. The gas withdrawal (small loop) warming coil, nested within the liquid withdrawal coil, warms the gaseous oxygen delivered when the H-300 is operating above economizer pressure.

12.9.1 Removal - Liquid Withdrawal Warming Coil

1. Remove the side covers (Section 12.2.1).

2. Use an adjustable wrench to hold the R/E valve outlet arm (with barbed fitting) stationary. Use a 7/16-in. open-end wrench to remove the liquid withdrawal warming coil compression nut from the R/E valve fitting.

3. Use a 5/16-in. open-end wrench to hold the fitting on the 1/16-in. diameter stainless steel container tube stationary. Use a 7/16-in. open-end wrench to remove the remaining liquid withdrawal coil compression nut from the fitting.

4. Pull the ends of the warming coil from their fittings and remove the warming coil.

12.9.2 Installation - Liquid Withdrawal Warming Coil

Install the liquid withdrawal warming coil by reversing the removal procedure.

NOTE: When installing a new warming coil, refer to Compression Fitting Makeup, Section 1.5.1.

12.9.3 Removal - Gas Withdrawal Warming Coil

1. Remove the side covers (Section 12.2.1).

2. Use an adjustable wrench to hold the R/E valve inlet arm (with secondary relief valve) stationary. Use a 7/16-in. open-end wrench to remove the gas withdrawal warming coil compression nut from the R/E valve fitting.

CAUTION: Be careful not to dent the top of the container when performing the following step.

3. Use an adjustable wrench to hold the vent valve mounting block on top of the container stationary. Use a 7/16-in. open-end wrench to remove the remaining gas withdrawal coil compression nut from the mounting block fitting.

4. Pull the ends of the warming coil from their fittings and remove the warming coil.

12.9.4 Installation - Gas Withdrawal Warming Coil

Install the gas withdrawal warming coil by reversing the removal procedure.

NOTE: When installing a new warming coil, refer to Compression Fitting Makeup, Section 1.5.1.

12.10 OXYGEN SUPPLY TUBE QUICK CONNECT & INLINE CHECK VALVE

The oxygen supply tube quick connect enables the patient to connect the H-300 to a flexible oxygen tube from the oxygen gas outlet of the HELiOS Reservoir. The patient can then breathe gaseous oxygen from the Reservoir through the H-300. The inline check valve allows oxygen to flow into the H-300 through the oxygen supply tube quick connect but prevents oxygen from flowing back out through the quick connect.

12.10.1 Removal - Quick Connect

1. Remove the side covers (Section 12.2.1).

2. Use a small flat blade screwdriver to carefully pry the 1/16-in. urethane tube from the inlet barbed fitting of the inline check valve.

3. Use a 5/8-in. open-end wrench to remove the nut that secures the quick connect to the H-300 front side cover. Pull the quick connect down and out of its mounting hole.

4. Remove the 1/16-in. urethane tube from the barb on the quick connect.

12.10.2 Installation - Quick Connect

Install the quick connect by reversing the removal procedure.

NOTE: Make sure that the quick connect release button faces forward when installing the quick connect in the side cover.

12.10.3 Removal - Inline Check Valve

1. Remove the side covers (Section 12.2.1).
2. Use a small flat blade screwdriver to carefully pry the 1/16-in. urethane tube from the inlet barbed fitting of the inline check valve.
3. Use a small flat blade screwdriver to carefully pry the 1/16-in. urethane tube from the outlet barbed fitting of the inline check valve.

NOTE: Barbed fittings on early inline check valves are removable. Barbed fittings on current inline check valves are not removable. The check valves are interchangeable and the check valve part number did not change.

12.10.4 Installation - Inline Check Valve

Install the inline check valve by reversing the removal procedure.

NOTE: Observe the flow direction arrow on the body of the inline check valve. Install the check valve with the flow arrow pointing to the urethane tube connected to the tee connector.

12.11 CRYOGENIC CONTAINER

The H-300 cryogenic container is a stainless steel, double-walled, vacuum-insulated container that holds liquid oxygen. The container's main function is to limit the amount of heat that leaks into the container from the surrounding atmosphere. The container is not field serviceable.

12.11.1 Removal

1. Remove the side covers (Section 12.2.1).

CAUTION: Be careful not to dent the top of the container when performing the following step.

2. Use an adjustable wrench to hold the vent valve mounting block on top of the container stationary. Use a 7/16-in. open-end wrench to remove the gas withdrawal warming coil compression nut from the mounting block fitting.

3. Use a 5/16-in. open-end wrench to hold the fitting on the 1/16-in. diameter stainless steel container tube stationary. Use a 7/16-in. open-end wrench to remove the liquid withdrawal warming coil compression nut from the fitting.

4. Remove the warming coils and R/E valve as an assembly.

5. Remove the female fill connector and tube (Section 12.4.1).

6. Remove the vent valve and tube (Section 12.5.1).

7. To prevent contaminants from entering the cryogenic container, place the container in a clean plastic bag and seal tightly.

12.11.2 Installation

Install the cryogenic container by reversing the removal procedure.

Section 13

HELiOS 300 ILLUSTRATED PARTS LIST

Section 13 contains six exploded view illustrations and related parts lists for the HELiOS 300 Portable.

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FIGURE 13-1 PARTS LIST - HELiOS 300 PORTABLE			
Item	**Part Number**	**Description**	**Qty.**
1	B-701542-00	Handle, HELiOS Portable	1
2	B-701594-00	Strap, Contents Indicator	1
3	B-701599-00	Screw, Torx Head, 6-19 x ¾-in. Plastite	2
4	B-701592-00	Pull Handle, Contents Indicator	1
5	B-701755-00	Pad, Non-Stick	1
6	B-775028-00	Pin, Hitch	1
7	B-701530-00	Label, Warning	1
8	B-701598-00	Screw, Torx Head, 6-19 x ½-in. Plastite	5
9	B-701593-00	Indicator Plate	1
10	B-701591-00	Spring, Contents Indicator	2
11	B-701539-00	Rear Side Cover	1
12	B-701586-00	Quick Connect, Oxygen Supply Line - (includes item 13)	1
13	Reference	Nut, Quick Connect	1
14	B-701538-00	Front Side Cover	1
15	B-701601-00	Knob Assembly w/Label	1
16	B-702007-00	Barbed Connector, 1/8-in. x 3/16-in. Tube	2
17	B-701597-00	C-clip	2

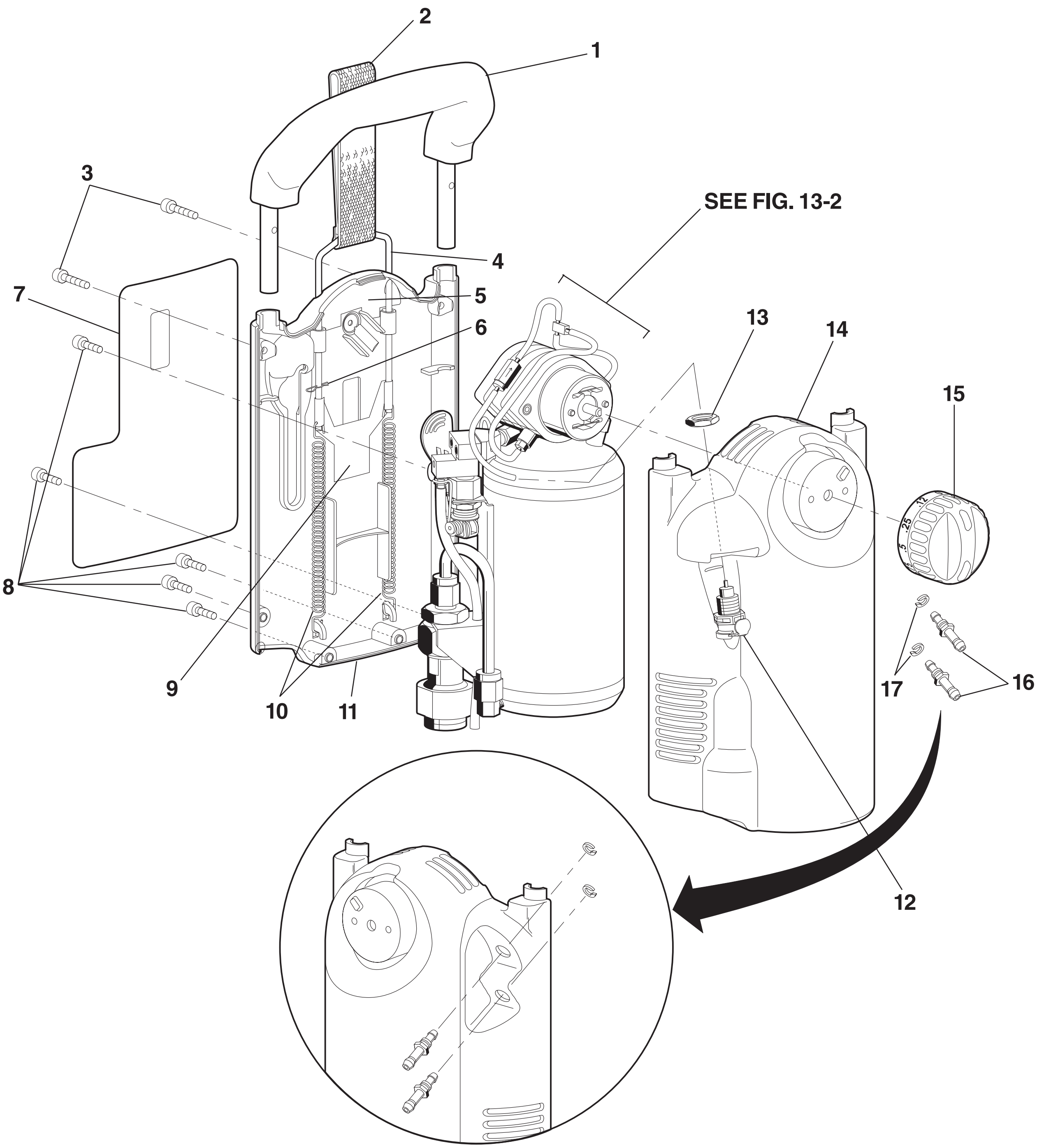

FIGURE 13-1
H300 Portable

FIGURE 13-2 PARTS LIST - HELiOS 300 PORTABLE			
Item	**Part Number**	**Description**	**Qty.**
1	B-777899-00	Screw, Socket Head Cap - 6-32 x ½-in. SS	2
2	B-701806-00	Lock Washer	2
3	B-701603-00	O-ring	1
4	Reference	Cryogenic Container	1
5	B-775063-00	Ferrule, Brass – ¼-in. Tube	2
6	B-775062-00	Nut, Aluminum – ¼-in. Tube	2
7	B-701588-00	Fill Tube – ¼-in. O.D. Aluminum	1

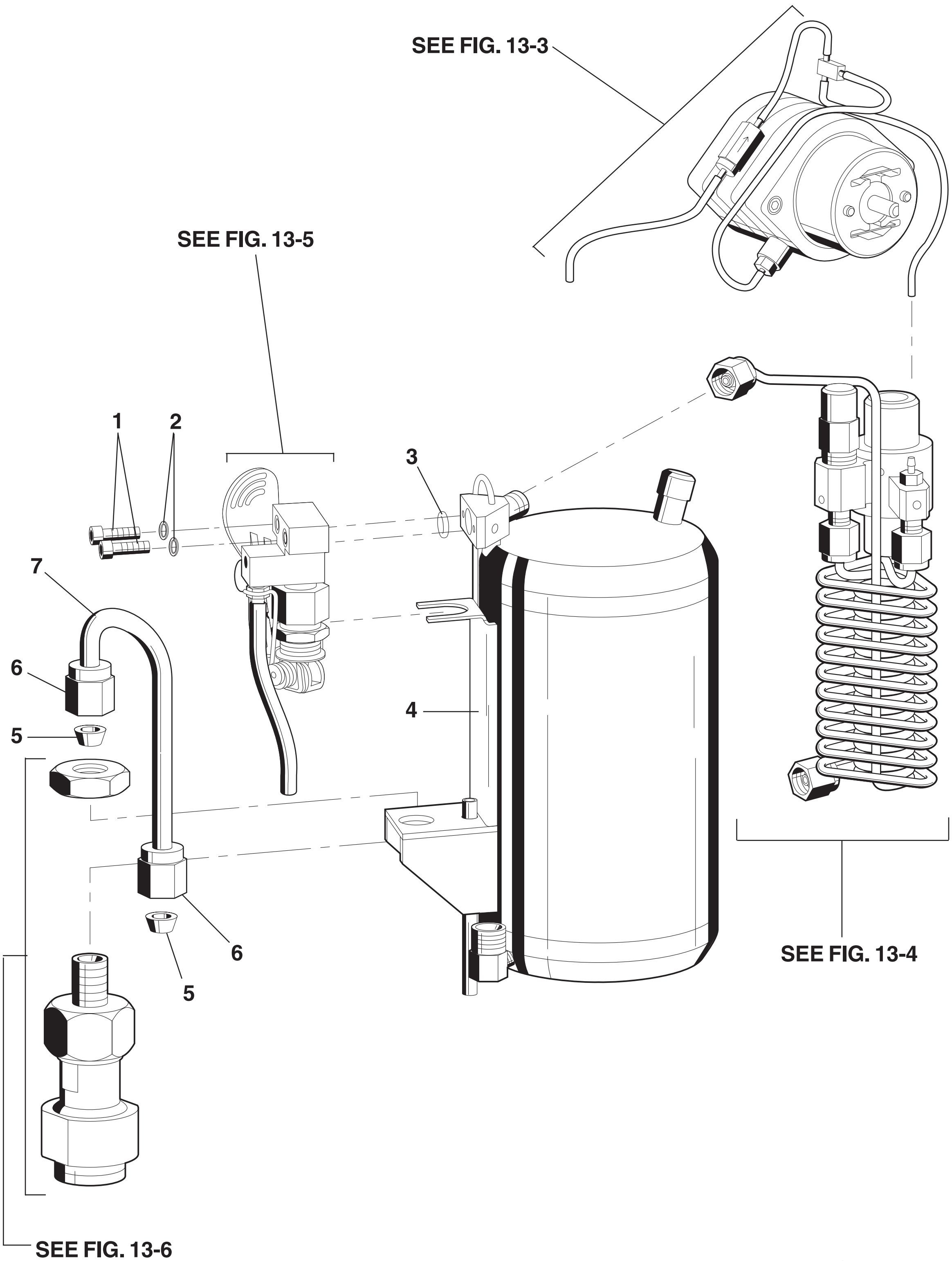

FIGURE 13-2
H300 Portable

FIGURE 13-3 PARTS LIST - HELiOS 300 PORTABLE			
Item	**Part Number**	**Description**	**Qty.**
1	Reference	Spring, Flat	2
2	B-701572-01	Demand Flow Control -- New	1
3	B-777736-00	Filter Screen	1
4	B-778167-00	Fitting, Brass – 1/16-in. Barb x 10-32	1
5	B-778157-00	Fitting, Brass – 1/8-in. Barb x 10-32	1
6	B-701685-00	Elbow, Nylon – 1/8-in. Barb	1
7	B-701585-00	Tubing, Silicone – 1/8-in. x 3-in.	2
8	B-701975-00	Tube Spring	2
9	B-701584-00	Tube, Black Flexible – 1/16-in. x 7 ½-in.	1
10	B-701582-00	Tube, Black Flexible – 1/16-in. x 2-in.	1
11	B-701587-00	Check Valve, Inline	1
12	B-701583-00	Tube, Black Flexible – 1/16-in. x 3-in.	2
13	B-701526-00	Tee, Barbed – 1/16-in. Flexible Tube	1

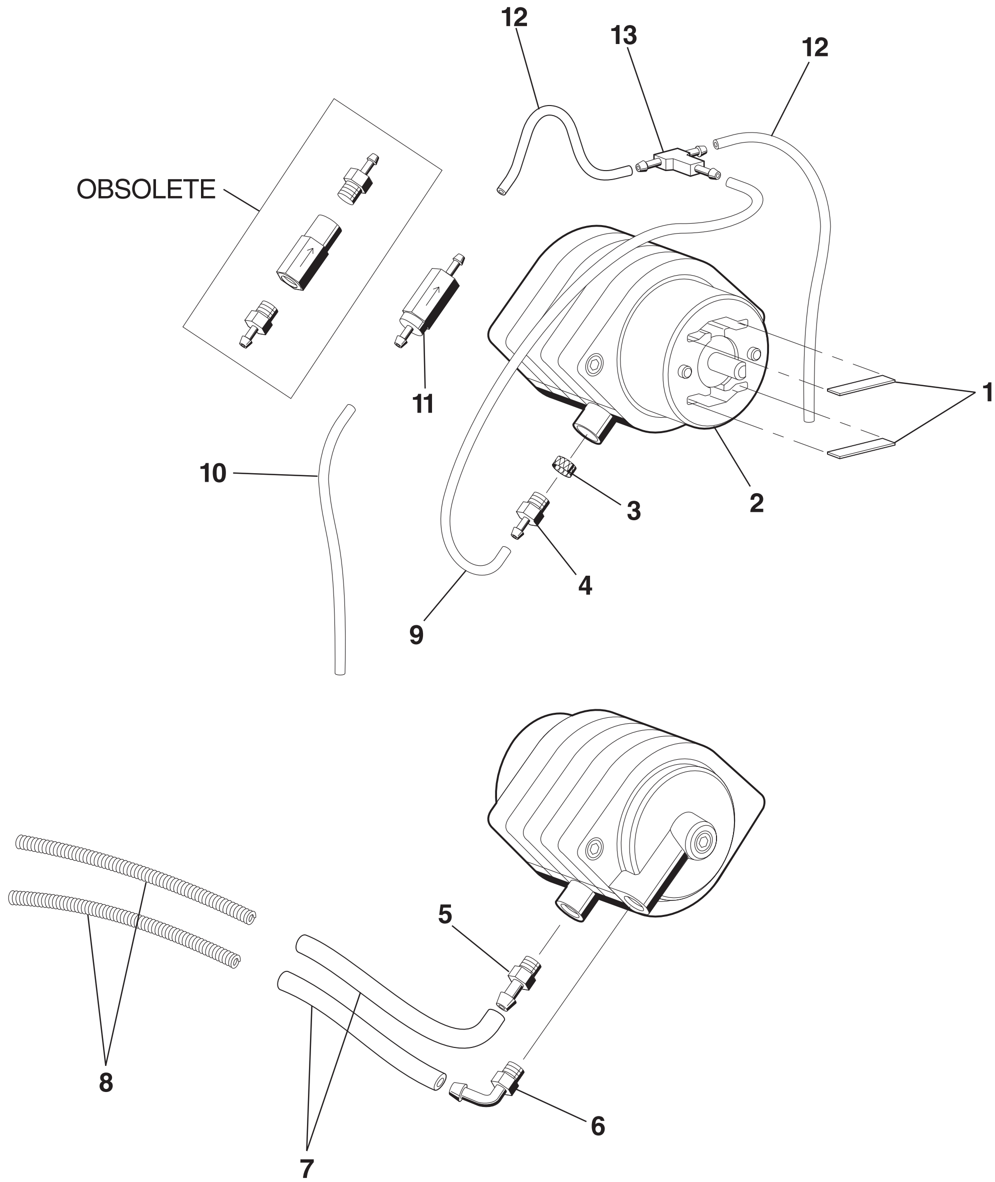

FIGURE 13-3
H300 Portable

FIGURE 13-4 PARTS LIST - HELiOS 300 PORTABLE			
Item	Part Number	Description	Qty.
1	B702075-00	Relief Valve, Secondary – 80 PSI	1
2	B-778167-00	Fitting, Brass – 1/16-in. Barb x 10-32	1
3	B-702074-00	Relief/Economizer Valve	1
4	B-701590-00	Ferrule, Brass – 1/8-in. Tube	4
5	B-701589-00	Nut, Aluminum – 1/8-in. Tube	4
6	B-701579-00	Warming Coil, Gas – 1/8-in. Tube	1
7	B-701577-00	Warming Coil, Liquid – 1/8-in. Tube	1

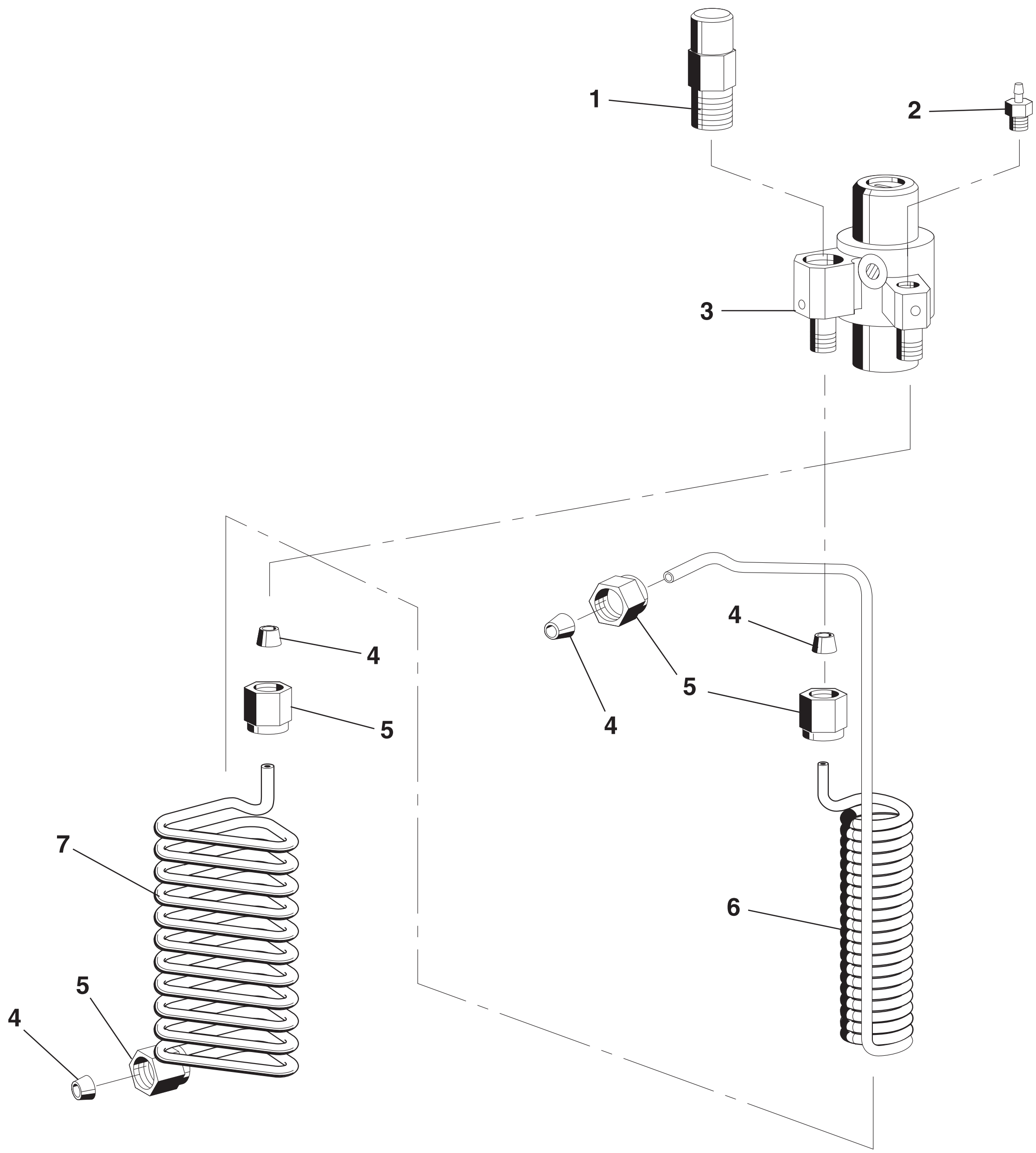

FIGURE 13-4
H300 Portable

FIGURE 13-5 PARTS LIST - HELiOS 300 PORTABLE			
Item	**Part Number**	**Description**	**Qty.**
1	B-702073-00	Vent Valve – (includes item 2)	1
2	Reference	Jam Nut	1
3	B-701335-00	Teflon Washer	1
4	B-775089-00	Spring Pin	1
5	B-701971-00	Lever, Vent Valve	1
6	B-701972-00	Torsion Spring	1
7	B-701738-00	Vent Tube, Flexible – 1/8-in. x 3.5-in.	1
8	B-778157-00	Fitting, Brass – 1/8-in. Barb x 10-32	1

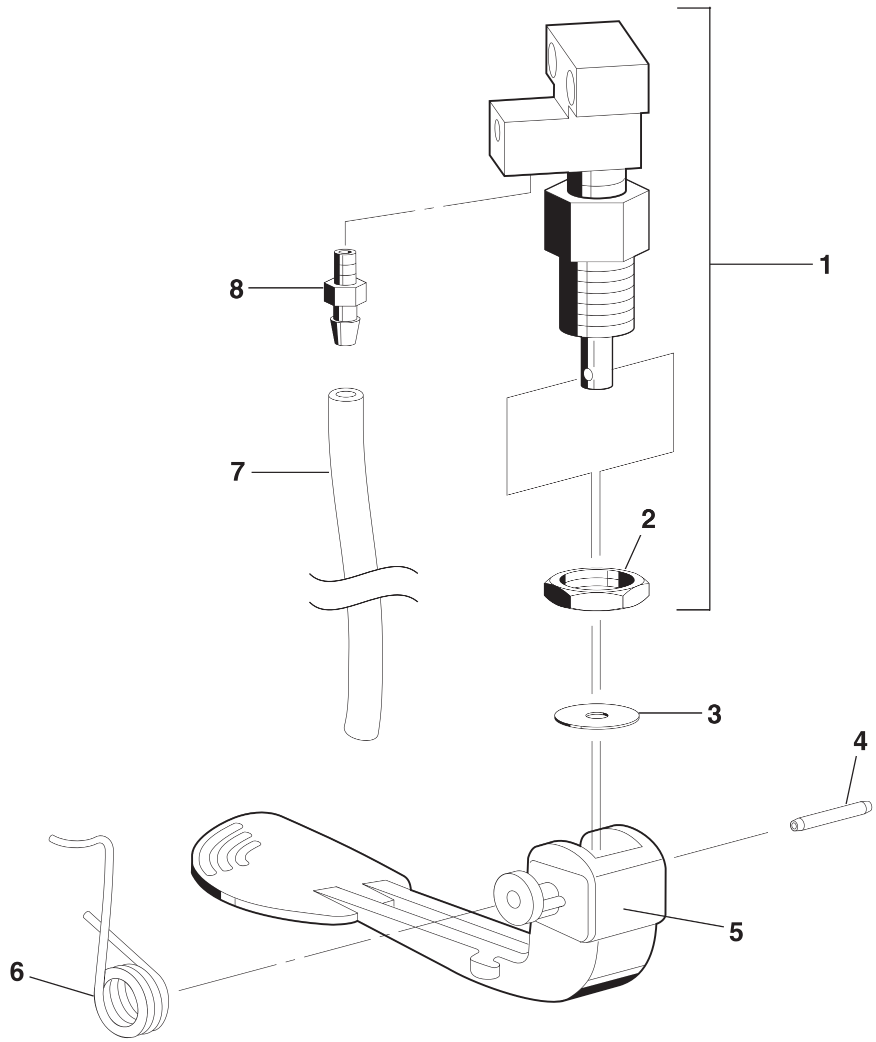

FIGURE 13-5
H300 Portable

FIGURE 13-6 PARTS LIST - HELiOS 300 PORTABLE			
Item	**Part Number**	**Description**	**Qty.**
1	B-702072-00	Female Fill Connector Assembly - (includes items 2, 3, 4, 5)	1
2	B-775261-00	Jam Nut, Female Fill Connector Adapter	1
3	B-775263-00	Adapter, Female Fill Connector	1
4	B-775262-00	Seal, Female Fill Connector Adapter	1
5	B-775264-00	Female Fill Connector – (includes items 4, 6, 7, 8, 9)	1
6	B-775259-00	Cartridge Assembly w/Retainer Ring	1
7	B-775267-00	Retainer Ring	1
8	B-775260-00	Lip Seal	1
9	Reference	Lip Seal Retainer Sleeve	1

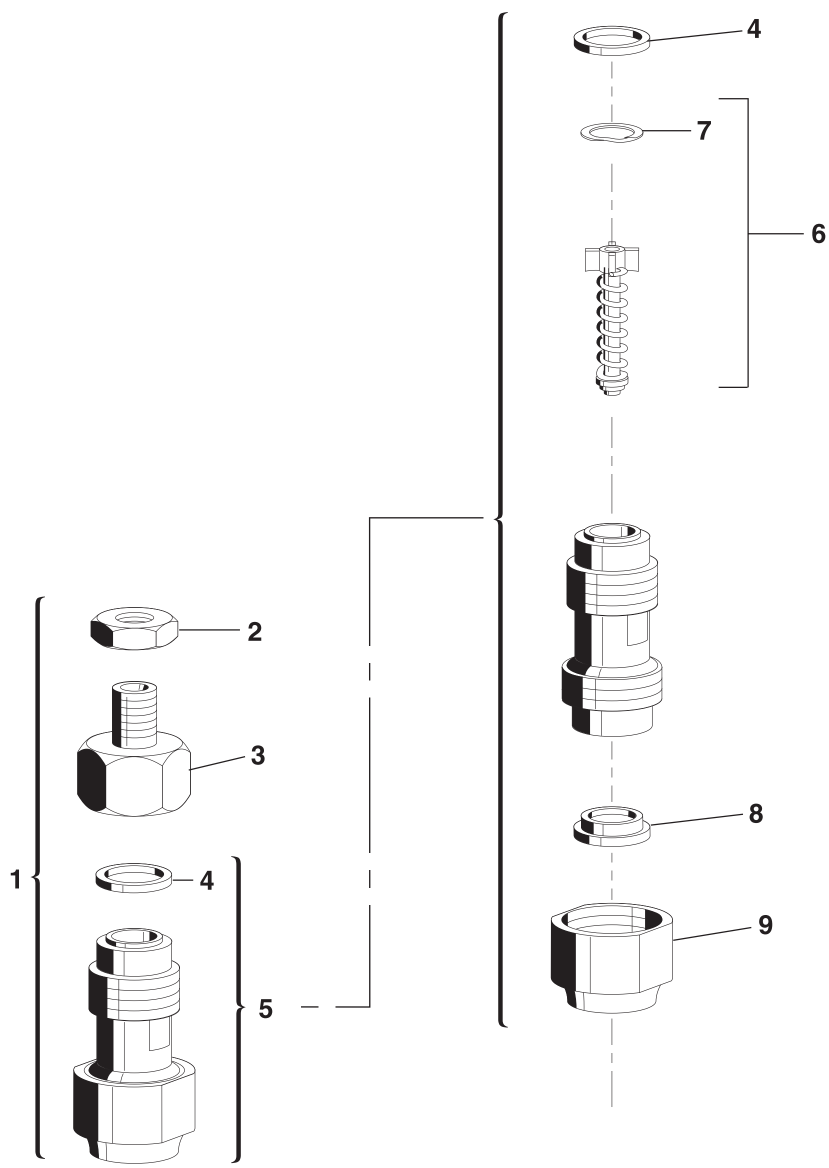

FIGURE 13-6
H300 Portable